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D'ÉGYPTE

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SOMMAIRE

SEPTEMBRE 1954

LE CAIRE

VU PAR LES VOYAGEURS OCCIDENTAUX DU MOYEN ÂGE[1]

PAR

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PROFESSEUR-ADJOINT À LA FACULTÉ DES LETTRES DE L'UNIVERSITÉ DU CAIRE

QUATRIÈME ARTICLE

xv^e^ siècle (suite) : 1. Josse de Ghistele, 1485 ; 2. Obadiah Jaré da Bertinoro, 1488 ; 3. Francesco Suriano, 1494 ; 4. Arnold von Harff, 1497.

JOSSE DE GHISTELE (1485)

Né à Gand en 1446, Joos van Ghistele, qui fut fait chevalier par Charles le Téméraire, était seigneur d'Axel et de Moere en Zélande, de Maelstede et autres lieux en Flandre. Il fut élu premier échevin de Gand en 1477, et le fut à nouveau en 1486 après son retour de Terre Sainte. Il fit son voyage en Orient dans les années 1481 à 1485. Parti de son château de Moere, près d'Axel en Zélande, il était accompagné de son frère Georges de Ghistele, de ses deux amis Jean van Vaernewyck et Georges Palingh, et de son chapelain Ambroise Zeebout. C'est ce dernier qui, à leur retour en Flandre, rédigea le récit du voyage.

Ils virent Rome avant de s'embarquer à Venise pour Beyrouth, visitèrent la Palestine, puis vinrent par Gaza au Caire, où ils logèrent chez un marchand chrétien natif de Malines, Francisco Tudisco, c'est-à-dire

[1] Voir les *Bulletins* de juin 1950 (t. XXIII), d'octobre 1951 (t. XXIV) et d'août 1953 (t. XXVI).

François le Flamand. Ambroise Zeebout ne nous dit pas la date exacte de leur arrivée au Caire ni la longueur des séjours qu'ils y firent; nous savons seulement par son récit qu'ils s'y arrêtèrent trois fois. Après une première visite de la ville et une audience du sultan Kaït Bey, ils allèrent voir Alexandrie, puis revinrent dans la capitale pour poursuivre ensuite vers Suez, le Sinaï, Aden et l'Arabie. De là ils revinrent encore au Caire et à Alexandrie, où ils s'embarquèrent vers la Syrie, et finalement pour Gênes. Ils se trouvèrent à Anvers, à la fin de ce voyage de quatre ans, le soir de la Saint-Jean (24 juin) 1485.

Josse de Ghistele a voyagé, « non par esprit de lucre, mais poussé par le désir pieux de visiter les Lieux Saints et aussi pour devenir par là plus expérimenté, plus sage et plus savant». Tel est le jugement de l'imprimeur Henri van de Keere dans la préface qu'il mit à son édition du *Voyage van Joos van Ghistele naar 't Heiligland,* à Gand, en 1557, in 4°.

Cette édition n'est pas, croit-on, la première, car il semble y en avoir eu une à Louvain, déjà en 1530 [1]; mais elle fut réimprimée plusieurs fois à Gand, et notamment en 1563, en 1572 et en 1672. C'est de l'édition de 1572 que nous nous servons pour traduire les passages essentiels de la relation d'Ambroise Zeebout concernant le Caire [2]. Nous regrettons vivement de n'avoir pu mettre la main sur une traduction française qui aurait paru à Lyon en 1564 [3].

On verra en lisant la description du Caire par Ambroise Zeebout que le jugement de l'imprimeur van de Keere n'est point erroné : nous avons ici, en effet, l'un des récits de voyage les plus intéressants du moyen âge, offrant un mélange attrayant de sincérité et de crédulité, de connaissances vraies et d'informations invraisemblables acceptées sans contrôle.

[1] A. G. B. Schayes, *Article sur Joos van Ghistele,* dans le *Messager des sciences de Gand,* t. IV, 1836.

[2] P. 153-174.

[3] Schayes, *ibid.*

Chap. V. *Site et disposition de la célèbre ville du Caire.*

Poursuivant le voyage (d'Alexandrie au Caire) et laissant de part et d'autre du chemin de nombreux villages et des maisons de campagne, on arrive à la ville du Caire, qui est assurément la plus grande que l'on connaisse au monde. Les sultans d'Egypte y ont leur résidence ordinaire. Arrivés dans la ville, les voyageurs descendirent pour se loger dans la maison d'un marchand né à Malines en Flandre et appelé Francisco Tudisco, à qui ils remirent des lettres de recommandation. Ce marchand, un orfèvre qui travaillait aussi le cristal, était très en faveur auprès du sultan et de la sultane. Aussitôt que les voyageurs furent descendus dans sa maison, la nouvelle de leur arrivée fut portée au Grand Interprète du sultan. Cet interprète, qui s'appelait *Antale Gaverdyn* [1], était un chrétien renégat, né à Valence en Espagne. Comme nos voyageurs lui étaient adressés, ils prièrent leur hôte de les conduire [chez lui], ce qu'il fit volontiers. A leur arrivée on leur demanda d'où ils venaient et où ils voulaient aller. Ils répondirent qu'ils venaient de Flandre, qu'ils avaient l'intention d'aller à Jérusalem et qu'ils désiraient visiter Sainte-Catherine et d'autres lieux dans les environs. Ils présentèrent à l'interprète une lettre du Gardien du Mont-Sion de Jérusalem.

Après ces formalités et l'acquittement des droits à l'interprète — droits qui se montent au Caire à cinq ducats par tête —, ils prirent congé de lui et rentrèrent à leur logis. Ils s'y reposèrent trois jours, puis firent une visite guidée de la ville.

Il leur apparut que celle-ci avait été autrefois entourée de murailles avec des portes, et que sa grandeur pouvait avoir été comparable alors à celle de la ville de Gand en Flandre; mais à présent elle s'est augmentée de tous côtés d'un si grand nombre de maisons que c'en est merveille, et elle s'étend maintenant comme une ville ouverte, sans murs ni fortifications. Elle est devenue si grande qu'on en ferait à peine le tour en douze heures à cheval. Elle s'étend beaucoup plus en longueur qu'en largeur et se développe à la manière d'une vallée, avec d'un côté une hauteur sur laquelle se trouve le château du sultan, et de l'autre côté le

[1] Gaber el-dîn?

cours du Nil. La ville ne touche pas la rivière sur toute la longueur de ce côté, mais seulement par les deux bouts, suivant une disposition qui représente assez bien le dessin d'une paire de lunettes : plus étroite en son milieu, elle s'y écarte de la rivière, mais elle y touche par ses deux extrémités qui sont sensiblement plus larges. L'une des extrémités du Caire aboutit de la sorte à une agglomération appelée Babilone, et l'autre à une autre agglomération appelée Boulac. Nous reviendrons plus loin sur cette disposition des lieux.

En son milieu, la ville peut avoir un demi-mille de large, et un mille environ à chaque extrémité. Elle est prodigieusement peuplée, car une même maison abrite trois ou quatre familles. Il est néanmoins impossible à la population de se loger toute entière dans la ville, faute d'habitations en suffisance : on voit de tous côtés un grand nombre de gens loger dans de petites tentes ou des pavillons, dans des trous ou dans des puits. Les rues de la ville sont si étroites que trois personnes y passeraient difficilement de front, et à certains endroits elles sont si sombres que les chauves-souris y volent aussi bien le jour que la nuit. Vers le milieu de la ville il y a deux belles et grandes rues appelées les Grands Bazars [1]. La foule y est si dense à toute heure du jour qu'il est difficile d'y passer. La plupart des maisons de ces rues sont de petits cafés ou des rôtisseries où l'on vend de la nourriture, du pain, de la viande, du poisson et toutes les espèces imaginables de fruits invitants et délicieux. Mais en fait de boisson on ne vend généralement que de l'eau. Le bois se vend au poids. La plupart des rues de la ville sont séparées des autres par des portes. On dit là-bas que la ville a bien dix mille *Gyemmen* ou mosquées — qui sont des temples ou des lieux de prière — érigées en l'honneur du prophète Mahomet, très belles et très riches, avec des minarets surmontés d'un croissant doré. On trouve à l'intérieur de la ville peu ou point de bonne eau, sinon celle qui est apportée du Nil; et il y a au Caire bien dix mille chameaux dont le seul emploi est de porter l'eau par toute la ville. Sur chaque chameau le sultan touche, à ce qu'on dit, un *maydin* [2] par jour, pièce

[1] *Le basares Kebier,* dans le texte.

[2] Le *maydin* était une petite pièce d'argent. Il y en avait 26 dans un dinar *ashrafi;* pièce d'or frappée par le sultan Barsbey et qui équivalait à un ducat.

de monnaie équivalant à peu près à trois gros de Flandre. Dans la ville il y a des belettes en si grand nombre qu'on les voit courir partout derrière les maisons aussi communément qu'ici les rats et les souris ; personne ne les prend ni ne leur fait de mal, car les belettes passent dans le pays pour empêcher la multiplication des serpents appelés basilics, lesquels sont dangereux et tuent tout ce qu'ils rencontrent ; les belettes les exterminent.

Au sujet de la disposition des maisons il est à remarquer que les maisons là-bas ont le plus souvent un toit plat, avec généralement une grande ouverture, et de grandes fenêtres grillagées par lesquelles pénètre le vent frais. Par les fortes chaleurs la température est si élevée qu'il est nécessaire d'arroser les maisons et les rues trois ou quatre fois par jour, sans quoi on ne pourrait vivre à l'intérieur ni marcher dans les rues.

On saura que dans la ville demeurent bien 18.000 chrétiens, qui sont des chrétiens de la Ceinture [1], des Ethiopiens [2], des Arméniens, des Géorgiens, des Nubiens ou des membres d'autres sectes analogues ; mais de ceux de notre confession, il n'y en a que fort peu et on les appelle là-bas des Francs. On dit aussi qu'il demeure au Caire bien 15.000 juifs exerçant presque tous des métiers manuels. Il y a aussi en ville une grande place où se vendent des esclaves qui sont des prisonniers amenés là de tous les pays...

CHAP. VI. *Des présents qu'ils firent au Grand Interprète pour obtenir une audience du sultan présent à ce moment au Caire.*

Après cette visite de la ville du Caire, ils retournèrent chez le Grand Interprète pour lui offrir un joyau apporté de Venise, qu'ils le prièrent d'accepter en gage de leur gratitude, et ils lui demandèrent par la même occasion de s'employer à leur obtenir une audience du sultan. Le Grand Interprète le leur promit et leur dit de se tenir prêts à être convoqués incessamment ; et en récompense du présent qu'il avait reçu d'eux, il

[1] Des Coptes.

[2] *Indianen,* dans le texte.

leur fit cadeau à son tour d'une petite ampoule de baume [1] et d'une bonne quantité de leur bonne thériaque. Deux jours après cette entrevue, il les fit mander en diligence pour être conduits chez le sultan. A leur arrivée il les instruisit de l'étiquette et du cérémonial à observer tant pour approcher le sultan que pour prendre congé de lui.

CHAP. VII. *Comment ils purent parler au sultan* (*Kaït Bey*). *Des marques de respect qu'on lui doit et du cérémonial à observer en sa présence. De la grandeur et de la richesse de son palais, ainsi que d'autres curiosités.*

Aussitôt qu'on arrive en la présence du sultan on doit se prosterner par trois ou quatre fois en baisant le sol et tout en continuant à s'approcher de lui. On fait alors à haute voix sa requête à l'un des serviteurs du sultan qui la lui répète. Et pour quitter le sultan on doit se retirer à reculons aussi longtemps qu'il reste visible, car on ne peut pas lui tourner le dos.

Instruits de toute cette étiquette, nos voyageurs furent conduits au palais. Celui-ci, qui est extraordinairement beau et riche, est bien aussi grand que la ville de Termonde en Flandre. Il est situé sur une élévation d'un côté du Caire.

Arrivés au palais, ils furent conduits par une dizaine de belles places, en passant des portes et des salles, et arrivèrent devant une habitation d'été remarquablement belle et construite entièrement en belles pierres de taille peintes d'or, d'azur et de toutes sortes d'autres couleurs précieuses. De cette maison on a vue de deux côtés, par de belles et somptueuses fenêtres grillagées et richement dorées, sur plusieurs jardins d'agrément avec des tonnelles et des vergers pleins de toutes sortes de plantes odoriférantes et d'arbres fruitiers. Il y a aussi un très grand nombre de fontaines, qui sont artificielles, mais ménagées avec art, et qui servent à arroser et à rafraîchir ces jardins et ces vergers.

Les visiteurs furent introduits dans cette maison, et l'intérieur leur en apparut la chose la plus riche qui se puisse imaginer au monde. Tant

[1] Du baume de Matarîya.

les murs que le pavement en sont entièrement incrustés de pierres polies de diverses espèces, de marbre blanc, noir ou rouge, de serpentine, de porphyre, de cornaline et d'autres pierres précieuses de tons divers; ils sont ornés en outre de peintures de couleurs variées, dessinant des nœuds, des torsades, des angles, des lettres arabes, et ils sont rehaussés de travaux de mosaïque ou d'autres, si richement qu'il serait difficile d'en donner une description exacte.

Au milieu de la maison règne une vasque carrée, d'une profondeur atteignant le genou, et large de trois ou quatre coudées; de petits poissons y nagent dans une eau très fraîche, perpétuellement renouvelée pour permettre au sultan de s'y rafraîchir les mains et les pieds quand il en a envie. Le sol de la maison était couvert de tapis d'un grand prix, sur lesquels étaient disposés en grand nombre des coussins recouverts de toile de lin, de soie ou de velours, quelques-uns aussi de drap d'or, ou encore de cuir de l'Inde dont la couleur est plus belle et plus particulièrement agréable.

C'est dans ce lieu que se tenait le sultan, assis sur un coussin, les jambes repliées à la manière des tailleurs, et jouant aux échecs avec un de ses seigneurs. Aussitôt qu'ils purent le voir, les visiteurs se prosternèrent, baisèrent le sol et approchèrent ainsi, en recommençant jusqu'à quatre fois, comme l'interprète le leur avait enseigné. Puis, arrivés devant le sultan, ils formulèrent à haute voix leur demande. Le Grand Interprète qui les avait introduits la répéta alors au sultan en la traduisant dans la langue du pays. Elle était à l'effet de prier son Altesse et sa Grandeur de vouloir bien accorder aux voyageurs des lettres et des saufconduits pour leur permettre de voyager en sécurité par ses territoires, étant bien entendu qu'ils ne désiraient pénétrer dans aucun des endroits généralement interdits aux chrétiens, comme la ville de la Mecque où l'on vénère le corps de Mahomet, le temple de Salomon et généralement toutes les mosquées et lieux de prière. Ils dirent aussi qu'ils étaient prêts à payer les droits qui seraient dûs pour tous passages, suivant les ordonnances du pays, et qu'ils ne désiraient rien d'autre que l'autorisation de voyager paisiblement par le pays du sultan pour le visiter à leur aise, sans plus.

Après les paroles de l'interprète, ils présentèrent au sultan des joyaux

qu'ils avaient fait faire à Venise à cette intention, et le prièrent de les accepter en hommage de gratitude. Leur requête entendue, le sultan y consentit aussitôt et il ordonna de donner aux visiteurs une ampoule de son baume et d'autres présents d'usage. Il les fit interroger en même temps sur l'état de leur pays, sur le cours des événements et particulièrement sur la personne de notre prince, feu le duc Charles [1] de sainte mémoire. Ils répondirent brièvement à ces questions, et ils prirent congé du sultan en se prosternant comme on leur avait indiqué de le faire.

Chap. VIII. *De la majesté et des titres du sultan.*

Lorsque le sultan accorde une audience solennelle, par exemple aux grands ambassadeurs ou à de hauts dignitaires envoyés par des princes ou des pays, il se montre dans une pompe triomphale. . .

Physiquement, selon ce que nos voyageurs purent observer de sa personne, c'est un homme de taille moyenne avec une longue barbe blanche. Il avait largement passé la soixantaine, mais on voyait bien qu'il avait dû être dans sa jeunesse un homme plein de grâce et de force, bien proportionné et de bonnes mœurs. Il était né de parents circassiens qui étaient des chrétiens renégats. Ses vêtements, toujours principalement de lin blanc, étaient très semblables sous tous les rapports à ceux que portent ordinairement là-bas les mameluks. Sur la tête il portait un turban blanc, haut enroulé, ondoyant, avec des pointes, tout comme un diadème. Voici, entre autres titres, ceux qui lui sont donnés dans les documents écrits : « Nous Kaït Bey, Sultan de Babilone, Roi des rois, Epée de Justice, Seigneur de deux Maisons Saintes et des deux Mers, Esclave de Mahomet le Prophète et l'Ombre de Dieu sur la terre. . .

Chap. IX. *De la richesse du sultan.*

Pendant le séjour de nos voyageurs au Caire il leur arriva ce qui arrive communément en pays étranger entre gens originaires d'un même pays ou de pays voisins. Dans la ville même habitait un mameluk, nommé

[1] Charles le Téméraire.

Nasr-el-Din, qui était né à Dantzig en Prusse. Il était trésorier du sultan et avait épousé une femme du pays, fille d'un musulman exerçant la fonction de clerc de la dépense du sultan, ce qui est un office considérable. Aussitôt que ce mameluk eut appris que des Néerlandais étaient arrivés dans la ville, il n'eut de repos qu'il ne les eût trouvés. Nos voyageurs firent ample connaissance et conversèrent longuement avec lui pendant le temps qu'ils passèrent au Caire et dans les environs, et ils apprirent de lui beaucoup de choses sur l'état et la puissance du sultan ainsi que sur la situation du pays. Entre autres choses, ce mameluk leur dit que le sultan entretient en permanence dans la ville bien 20.000 mameluks à sa solde, sans compter le nombre considérable de ceux qu'il a en divers endroits dans l'ensemble de ses territoires. Sur ces 20.000 mameluks, 10.000 sont nourris dans le château et y logent toutes les nuits. Et sur ces 10.000, environ sept ou huit mille sont des adolescents ou de jeunes garçons de dix-huit, douze, neuf, huit ou sept ans, ayant renié la sainte foi chrétienne, et appelés là-bas *Gelepij* [1]. Ces *Gelepij* sont instruits dans trois maisons d'éducation extraordinairement grandes qu'on appelle là-bas *Tabigoes*. Ils sont séparés en divisions suivant un règlement, et ont dans toutes les salles un grand nombre de maîtres différents qui leur apprennent à lire et à écrire la langue arabe et qui leur enseignent aussi l'Alcoran, qui est la bible contenant tous les articles de la loi de Mahomet. Il y a aussi dans ces écoles un très grand nombre de maîtres qui apprennent à ces jeunes gens le maniement de l'épée et du poignard, de la dague, de la hache, de la lance, la lutte et le tir à l'arc; et ils sont en butte à bien des misères avant d'en avoir fini de tout ce programme. Mais quand ils ont appris tout cela ils sont promus graduellement des écoles inférieures dans d'autres plus avancées; et ceux qui ont terminé l'école supérieure sont faits mameluks. Dans l'école inférieure sont mis de nouveaux garçons originaires de diverses nations et qui sont amenés là en vente et achetés nouvellement tous les jours, si bien que ces écoles ne sont jamais vides. Quant aux deux mille autres mameluks qui sont également logés et nourris dans ce château fortifié, ils sont officiers au service du sultan.

[1] De l'arabe Gallabi (?) = surveillant d'esclaves.

Et sur les 20.000 mameluks dont nous parlons, les dix mille restants sont des mameluks stipendiés qui logent en ville et qui viennent tous les jours à la cour, à pied ou à cheval, en pelotons de cinquante ou de cent approximativement, sous différents capitaines et seigneurs, et toujours prêts aux ordres du sultan ou de leurs commandants.

Nasr-el-Din dit encore que le sultan a à ses ordres quantité de gouverneurs en divers endroits pour la garde du pays et des frontières. Chacun d'eux a ses attributions et commande à un certain nombre de mameluks. Et ce sont les seigneurs de Damas, de Tripoli, de Balbek, d'Amman, de Homs, de Smyrne, d'Alep, d'Albier, d'Antioche, de Carran, de Jaffa, de Tibériade, d'Acre, de Jérusalem, de Rama, de Gaza, de Katâya, de Bilbeis, de Damiette, d'Alexandrie, de Tor, de Djedda, de Kosseir et de beaucoup d'autres places qu'il serait trop long d'énumérer.

Le mameluk Nasr-el-Din nous dit aussi que chacun des mameluks à la solde du sultan reçoit dix ducats de gages par mois, ce qui constitue un traitement extraordinairement élevé. Il dit encore que lorsque le sultan fait la guerre — ce qui arrive constamment dans un coin ou l'autre — chaque mameluk reçoit cent ducats d'indemnité d'équipement, deux bons chevaux et un chameau pour porter ses bagages et ses provisions, outre la solde mensuelle de dix ducats dont nous venons de parler et qui lui est continuée.

D'autre part les mameluks considèrent comme un usage établi qu'à la nouvelle de la naissance d'un enfant mâle chez le sultan, chaque mameluk reçoive cent ducats. Et il naît, en effet, des garçons au sultan, mais on évite d'en publier la nouvelle afin d'éviter cette grande dépense. L'usage que nous mentionnons ici a été établi primitivement par les mameluks en vue d'empêcher les sultans de transmettre leur pouvoir à leurs fils par succession ou héritage, ce qu'ils ont, en effet, essayé de faire dans les temps passés, notamment sous le Diudar [1] Hameth qui aurait peut-être réussi s'il était resté en vie; mais ils n'y ont plus jamais réussi depuis que les mameluks se sont assuré du pouvoir.

[1] Ce titre sera expliqué plus loin par l'auteur, au chapitre XIII.

CHAP. XI. *De la dépense journalière du sultan. De la sultane et du harem.*

Nasr-el-Din leur parla encore des grands frais qu'occasionne journellement l'entretien du sultan. D'abord il faut lui fournir six cents moutons, trente bœufs ou vaches sans compter les veaux, les chèvres, les chapons, les poules, les oies, les pigeons et les quantités énormes de gibier de poil et de plume de toute espèce. A ces approvisionnements sont préposés deux Grands Emirs qui n'ont d'autre rémunération que les peaux, les langues et les queues des bêtes livrées, mais cela représente un revenu inestimable.

Nasr-el-Din dit aussi que le sultan reçoit tous les ans, par toute l'Egypte, le cinquième des ensemencements et des moissons des paysans. Cette disposition remonte au temps où le patriarche Joseph fut chargé par le roi Pharaon d'emmagasiner de grandes quantités de grain pour les sept années de disette annoncées au roi par un songe que Joseph interpréta sur une révélation de Dieu, ainsi qu'il est rapporté dans le livre de la Genèse.

Nasr-el-Din dit encore que les sultans ont à leur service deux émirs commandant chacun à deux cents mameluks, qui, tant émirs que mameluks, sont faits eunuques; car aucun autre homme que ces eunuques, appelés là-bas *Tawashi,* ne peut pénétrer dans le lieu des femmes. Le lieu où se tiennent les femmes est un endroit fermé, très beau et très grand, à l'intérieur du château du sultan, et l'on peut passer secrètement de l'un à l'autre.

Nasr-el-Din raconta aux voyageurs comment les sultanes avec toutes leurs femmes, qui sont bien au nombre de cinq ou six cents, reçoivent le sultan à son retour d'une guerre, d'un pèlerinage ou de quelque long voyage. Elles se rassemblent dans une longue galerie, les unes jouant de divers instruments, les autres chantant des mélodies variées, et quelques-unes aussi dansant à la mode du pays, ce qui fait un spectacle étrange et très agréable à voir et à entendre. . .

CHAP. XII. *De la pompe du sultan quand il chevauche avec sa suite, ainsi que des jeux et exercices de ces gens.*

Pendant leur séjour au Caïre nos voyageurs virent à plusieurs occasions le sultan sortir à cheval de son palais pour se rendre en promenade hors de la ville, par la campagne, dans divers endroits frais et agréables. C'est un spectacle magnifique et étonnant que celui de tous ces seigneurs, diudars, émirs et mameluks chevauchant avec lui, chacun selon son rang et d'après son état, et presque tous vêtus de lin blanc; et la foule est alors si nombreuse que toute la population de la terre semble être rassemblée. Et de la même manière que chez nous les princes vont précédés d'un porteur d'épée, on porte devant le sultan une petite hache richement dorée. A sa suite — toujours d'après ce que virent nos voyageurs— douze chevaux sont conduits trois par trois; ce sont des coursiers, des genêts, des chevaux barbaresques et turcs, aux caparaçons si richement ornés d'or, de perles et de pierres précieuses que la valeur en est inestimable. Ces chevaux ne sont pas montés, mais menés à la main; et derrière eux viennent quatre chameaux de course, qui sont des dromadaires. Ces bêtes sont si rapides qu'elles couvrent en une journée de voyage plus de distance que les chevaux en quatre; aussi ceux qui les montent à l'allure de course doivent-ils s'envelopper la tête dans un châle serré, pour éviter le vertige. Ces chameaux étaient, eux aussi, recouverts de housses à la mode du pays, si précieuses qu'il serait impossible de les décrire. Et c'est bien là un luxe particulier aux seigneurs de ce pays, où tout prince, quand il chevauche, se fait ordinairement suivre de dromadaires, tantôt d'un, tantôt de deux, de cinq ou parfois de plus encore, à leur volonté.

Nos voyageurs assistèrent aussi une fois à un jeu ou passe-temps qui se pratique là-bas et qui est appelé *Ala Bala*. Il ressemble assez au jeu de la crosse dans notre pays, mais il doit se jouer à cheval. La partie que nos voyageurs virent eut lieu dans le château et le sultan y prit part lui-même avec un grand nombre d'autres seigneurs divisés en deux camps par nombre égal. Chaque seigneur tient à la main un maillet dont l'extrémité rappelle par sa forme une crosse. Au milieu du terrain est placé une balle gonflée d'air, plus grosse qu'une tête d'homme. Ils la frappent de leurs crosses pour l'envoyer suivant certaines règles, comme on le fait dans nos pays avec la balle de buis. Cela se passe là-bas si brutalement qu'ils se renversent souvent les uns les autres et se brisent bras et jambes. Et quand par hasard la crosse du sultan lui échappe de la main et tombe à terre, on voit les mameluks se précipiter et rivaliser à qui la ramassera : car celui qui peut la lui rendre gagne le cheval que monte le sultan et tous les vêtements qu'il porte.

CHAP. XIII. *Des ambassades envoyées de Naples et de Chypre au sultan, et des présents faits par celui-ci à la reine de Chypre.*

Pendant le séjour de nos voyageurs au Caire deux ambassades arrivèrent au sultan de pays différents. La première était envoyée par le roi de Naples pour traiter avec le sultan au sujet de l'île et du royaume de Chypre au profit du fils bâtard du roi qui séjournait en ce moment à la cour du sultan. Pour mieux assurer ses desseins le roi envoyait au sultan un beau navire chargé de matériel de guerre. . . Arrivés au Caire ces ambassadeurs, avant de se rendre chez le sultan, prièrent tous les chrétiens de notre confession qui se trouvaient dans la ville de vouloir bien les accompagner à la cour pour grossir leur compagnie, et nos voyageurs s'y trouvèrent invités comme les autres.

Ils se mirent en route et arrivèrent au château dont ils trouvèrent fermée la porte principale; mais elle leur fut ouverte aussitôt qu'on sut que l'ambassade se présentait. Ils entrèrent, et on referma la porte sur eux. A l'intérieur ils se trouvèrent en présence d'un émir, c'est-à-dire d'un capitaine commandant à cent mameluks au moins, de garde à la porte avec tous ses hommes vêtus et équipés à l'ordonnance, qui jouaient et se distrayaient de diverses manières tout en examinant l'ambassade, mais sans s'occuper autrement d'elle. La porte en question est voûtée à l'intérieur, et la voûte est si grande qu'elle couvre une véritable salle toute tendue de tapisseries et de draperies de soie. De là, en traversant une place, les ambassadeurs furent conduits à une autre porte qu'ils trouvèrent également fermée et qui leur fut ouverte et refermée sur eux comme la première. Elle était également gardée par des hommes d'armes,

mais plus nombreux qu'à la première porte et pressés les uns contre les autres. Plus loin, nos voyageurs passèrent bien encore huit ou neuf portes successives, toutes gardées de plus en plus étroitement par des hommes d'armes qui les refermaient toujours sur leur passage.

Ayant franchi toutes ces portes, ils arrivèrent sur une grande place en rectangle dont les côtés dépassaient en longueur un trait d'arc. Elle était pleine de grands seigneurs, diudars, émirs et mameluks qui offraient un merveilleux coup d'œil. Presque tous étaient habillés, suivant l'usage du pays, d'un lin dont la blancheur était éblouissante au soleil. Tous se tenaient immobiles et en silence, on n'eût entendu parler, tousser ni cracher personne. Ils avaient formé la haie sur le passage par où devaient avancer les ambassadeurs avec leur suite.

Arrivés sur cette place, ceux-ci virent, contre le mur d'un bâtiment plus grand que l'hôtel de ville de Bruxelles, le *mastabem* du sultan, c'est-à-dire l'estrade royale dont nous avons parlé plus haut, haute d'environ une taille d'homme, avec de larges degrés d'accès. A côté se tenait un jeune homme, robuste et dispos, un pied sur une marche et la main à la garde du cimeterre (qui est une sorte d'épée), dans l'attitude d'un homme prêt à dégaîner. L'estrade était recouverte de riches draps d'or et de quantité de coussins de diverses étoffes, et le sultan y était assis sur un siège bas, de la forme d'une chaise d'église pour femme, et d'environ un demi-pied de haut. A sa gauche, sur un coussin, était posée une épée nue avec un bouclier d'or. Du côté droit de son siège quatre ou cinq poteaux dressés soutenaient une toile tendue comme un toit de tente pour lui donner de l'ombre. Sous la toile étaient assis aussi les trésoriers, les secrétaires, les clercs et les autres scribes, chacun selon son rang, en belle et bonne ordonnance.

A leur arrivée et dès qu'ils aperçurent le sultan, les ambassadeurs s'agenouillèrent jusqu'à quatre fois en baisant le sol, et tous ceux qui les accompagnaient firent de même. Et quand ils se furent approchés à douze coudées du sultan on les fit s'arrêter et on leur donna l'autorisation de formuler à haute voix leur message, ce dont s'acquitta l'un des ambassadeurs qui avait été mandaté pour cela. Mais ce ne fut là qu'un commencement, car aussitôt que l'ambassadeur eut fini de parler, le Grand Interprète du sultan, nommé *Antale Gaverdyn,* reprit son discours

et le traduisit à haute voix en langue arabe en s'adressant à un seigneur appelé *Nader Calse* qui se tenait debout à environ trois coudées de lui, plus près du sultan, et sur la gauche de celui-ci. Ce seigneur, qui remplit en quelque sorte l'office de chancelier, répéta à son tour les paroles de l'ambassadeur en s'adressant à un troisième seigneur debout à environ trois coudées de lui et encore plus près du sultan. Ce dernier seigneur, appelé Hassan Bey et qui a le titre de Grand Emir [1] est le plus haut dignitaire de la cour du sultan et le chef des émirs. Lorsqu'il eut entendu la proposition, il s'approcha du siège du sultan et lui répéta de nouveau, à haute voix et de la même manière que les autres, le discours que le sultan avait pourtant entendu déjà clairement.

En cas d'absence de l'un des deux seigneurs ici nommés il y en a deux autres qui ont pour fonctions de les remplacer dans les pourparlers. L'un a le titre de *Diudar* [2], et ce titre équivaut à peu près à celui de connétable en France, car il a entièrement dans ses attributions la garde de toutes les frontières, le commandement de toutes les forces de l'armée et de la marine, et la direction administrative de toutes les guerres. L'autre a le titre de *Katib el-Sîr* [3]; c'est en quelque sorte l'argentier, le trésorier ou le préposé aux finances. Et ce sont ces quatre seigneurs qui administrent et gouvernent presque exclusivement le pays du sultan...

Les discours finis, le sultan, sans prendre conseil ni délibérer, fit lui-même sa réponse à haute voix. Après quoi les ambassadeurs prirent congé de lui et se retirèrent à reculons, à la manière prescrite, en baisant le sol par quatre fois comme ils l'avaient fait en arrivant.

La deuxième ambassade qui vint au Caire à la même époque était envoyée par la reine de Chypre avec le payement du tribut annuel que cette reine doit au sultan, en même temps que celui des deux années précédentes en retard de payement. Ce tribut, qui est de 7.000 ducats, est dû tous les ans.

Le jour où cette ambassade dut se rendre chez le sultan, tous les chrétiens furent à nouveau invités à s'y joindre pour grossir le groupe,

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(1) *Hassenbec Lemyerkebier.*

(2) *Le Dendaert.*

(3) *Le Cattibyssar.*

et en arrivant au château ils virent toutes les mêmes choses et observèrent le même cérémonial que la première ambassade.

Celle-ci étant terminée, et l'accord conclu au sujet du payement, il se passa une chose très remarquable : le sultan envoyait à la reine une robe brodée d'or à la façon musulmane, ainsi qu'un cheval d'une grande beauté, une épée d'or et une paire d'éperons dorés, le tout avec un cérémonial approprié. Il agit de même à chaque payement et montre par là qu'il tient le roi ou la reine de Chypre pour son esclave ne possédant le royaume que par sa permission. L'ambassadeur principal fut également revêtu d'une robe du sultan. Après avoir pris congé de la manière décrite plus haut, cet ambassadeur, emportant les présents adressés à la reine, fut reconduit officiellement et en grande pompe à son logement par un groupe de seigneurs.

Chap. XIV. *Du site de la ville de Babilone, et d'autres curiosités.*

Pour continuer notre propos, les voyageurs ayant ainsi passé quelque temps au Caire, où ils virent tout ce que nous avons dit, furent menés à une agglomération située à environ un quart de mille de distance au bord du Nil et appelée là-bas Babilone. . . Le grand nombre des maisons de plaisance entourées de beaux jardins et de vergers, ainsi que celui des lieux de prière musulmans situés entre cette agglomération et le Caire, font que les deux ne semblent faire qu'une même ville. . .

On y montre, au milieu du Nil, une jolie petite île que les musulmans appellent Gezira [1], si bien entourée de murailles et de digues, que la crue de la rivière ne peut lui causer aucun dommage. C'est assurément l'un des endroits les plus agréables que l'on puisse imaginer, et il y a là un bon nombre d'habitations. A l'extrémité d'amont se dresse une riche mosquée de Mahomet, fortifiée comme un château-fort, avec une grande tour d'angle qui brise le courant de la rivière et garantit l'île, laquelle sans cela serait enlevée par les eaux. C'est à cette tour qu'on a coutume de mesurer tous les jours la crue de la rivière ; et la nouvelle se porte au sultan, comme il sera dit ci-après.

[1] *Carissius,* dans le texte.

On dit aussi là-bas que dans le Caire et dans Babilone s'élevaient autrefois vingt-cinq belles églises chrétiennes. Quelques-unes existent encore, pauvrement entretenues par les chrétiens du pays, Abyssins, Jacobites, Syriens, Arméniens, Géorgiens et autres ; mais il y en a bien plus dans la partie habitée de Babilone qu'au Caire.

Nos voyageurs furent conduits d'abord dans une église appelée là-bas la Cave Babilone [1], et c'est assurément une église très convenable et recueillie. En y pénétrant et en contournant le chœur par la droite, on descend par dix marches dans une chapelle dont la voûte est soutenue par trois piliers : c'est là, d'après la tradition locale, que la Sainte Vierge séjourna quelque temps lorsqu'elle eut fui la Terre Promise pour se réfugier en Egypte avec Jésus et Joseph. Dans cette chapelle, près de la sortie, on voit dans le mur un trou à peu près de la grandeur d'un four, pieusement orné et embelli de marbre. Au milieu de ce trou une croix est creusée dans la pierre : c'est là, toujours suivant la tradition, que Notre Dame, dans sa crainte des Juifs, avait coutume de cacher son Fils Jésus quand quelque bruit l'inquiétait. Près de ce trou, à main droite, il y a une sorte de citerne où Marie avait coutume de laver les linges de Notre Seigneur Jésus. Nombre de personnes pieuses qui subirent là-bas le martyre pour la foi chrétienne ont été depuis ensevelies dans cette citerne. Elle est à présent fermée d'un couvercle à la façon d'un toit de four, et on n'y peut plus puiser de l'eau. L'endroit et l'église sont restés là-bas des lieux très vénérés.

Quittant cette église, les voyageurs furent conduits dans une autre belle église dédiée à la glorieuse martyre Sainte Barbe. A la hauteur du chœur on y montre, encastré dans un mur à main gauche, une sorte de tombeau garni de grilles de fer, où l'on conserve la tête de la Bienheureuse Vierge Barbe, si bien conservée qu'elle semble avoir été coupée depuis peu. C'est là aussi un objet tenu en grande vénération là-bas.

Nos voyageurs furent ensuite conduits dans une autre église qui, de l'extérieur, ressemblait à une maison en ruines. Cette église est tenue là-bas en plus grande vénération encore que les autres : elle est appelée

[1] *Le cana Babylonia (sic).* C'est l'église appelée au moyen-âge Sainte-Marie-de-la-Cave. Aujourd'hui Saint-Serge (Abu Sarga).

Notre-Dame de la Colonne, à cause d'un grand miracle qui s'y produisit dans les temps passés, comme il sera dit ci-après.

Chap. XVI. *Description de l'église de la Colonne.*

Cette église se dresse à une certaine hauteur, et il faut y monter par vingt-neuf marches. La nef a seize colonnes soutenant une large voûte. Le chœur se trouve un peu sur la droite par rapport à l'entrée, et il a quatre piliers de marbre blanc. De ces piliers, le premier à gauche est celui d'où est sortie la voix miraculeuse à laquelle nous avons fait allusion, et c'est de lui que l'église a tiré son nom. Cette église est très vénérée là-bas, ainsi que la colonne, devant laquelle sont suspendues un grand nombre de lampes perpétuellement allumées. A gauche du chœur, en entrant, règne une cloison disposée à la manière grecque, en bois de cyprès incrusté d'ivoire et de nacre, et où se trouvent plusieurs autels. Il y en a un notamment à la Sainte Vierge, qui a aussi donné son nom à l'église. Devant cet autel pendent bien trois cents lampes de toutes dimensions. . .

Chap. XVII. *Des jardins variés, parcs et tonnelles, pleins d'arbres curieux, de fruits et de plantes, situés entre Babilone et Boulac.*

De Babilone, les voyageurs furent encore conduits pendant un quart de mille environ, en descendant toujours le long du Nil, jusqu'à une fort belle agglomération appelée Boulac, bien plus grande que Babilone, mais sans portes ni murailles, et qui s'étend en longueur au bord de la rivière, avec de belles et riches maisons pleines de marchandises de toutes les espèces imaginables. Car cet endroit est l'entrepôt principal de toutes les marchandises apportées au Caire des pays avoisinants, comme le Saïd [1], la Haute-Egypte, Alexandrie, Damiette et d'autres endroits. Elles sont apportées par des bateaux qui remontent et descendent la rivière ; et ce spectacle est si extraordinaire que nul ne pourrait le décrire. C'est aussi à cet endroit que l'on puise la plus grande quantité de l'eau fraîche utilisée au Caire, car la ville, ainsi que nous l'avons dit, a peu

[1] *Sayetten.*

d'eau. Boulac est à peu près à la même distance du Caire que Babilone, en sorte que les trois forment comme un triangle dont tout l'ensemble est appelé le Caire. Et bien que les rues qui mènent du Caire à Babilone, de Babilone à Boulac, et de Boulac au Caire, soient bâties et habitées, il y a entre ces trois agglomérations des espaces libres avec des jardins, des lieux d'agrément, des tonnelles et des vergers, si bien qu'il est impossible de décrire tout cela. Ces lieux pleins de petites maisons de plaisance, la variété des plantes délicates et odoriférantes et des arbres fruitiers de tout genre, tout cela est merveilleux et fait penser à un paradis terrestre.

OBADIAH JARÉ DA BERTINORO (1488)

Ce voyageur juif d'origine italienne, qui fut l'un des rabbins les plus distingués de son temps, est connu surtout pour son ouvrage appelé communément le *Bertinoro :* c'est un commentaire de la *Mishna,* ou première partie du *Talmud,* qui contient le bref exposé des lois religieuses, morales et civiles de la religion judaïque.

Emigré en 1487 de Città di Castello où il résidait, Obadiah da Bertinoro alla s'installer en Palestine. Il s'embarqua à Palerme sur une galère française à destination d'Alexandrie, et se trouva à bord avec son coreligionnaire Meshullam de Volterra, dont c'était, semble-t-il, le second voyage en Orient. Mais Meshullam se rendait cette fois à Constantinople et changea de bateau à Rhodes. Obadiah da Bertinoro débarqua à Aboukir, passa sept jours à Alexandrie, et arriva au Caire par le Nil en janvier 1488. Il passa dix-huit jours au Caire avant d'aller s'établir à Jérusalem, où il mourut vers 1500.

La relation de son voyage a été traduite en anglais par Elkan Nathan Adler, dans ses *Jewish Travellers* [1]. Nous en extrayons, pour les traduire en français, les passages qui décrivent le Caire [2].

« Avant d'arriver à Boulak, nous aperçûmes deux très vieilles constructions en forme de dômes, toutes deux sur le même côté du fleuve.

[1] London, G. Routledge, 1930, in-8°.
[2] P. 224-225, 228-229 et 230-231.

Ce sont, dit-on, les magasins que Joseph a construits. L'entrée en est sur le sommet. Si ruinées que soient ces constructions, on se rend bien compte qu'elles ont dû être de magnifiques édifices. La région est inhabitée.

« Douze jours avant Purim [1], vers le soir, nous arrivâmes au Caire. C'était l'époque de la grande moisson, et la fin de la grande disette qui avait régné dans toute la région du Caire. Ici l'orge mûrit plus tôt qu'ailleurs, grâce aux eaux du Nil; et la moisson paraissait excellente. Le mois suivant il y eut grande abondance, si bien qu'il ne fut plus question de famine. Comme les habitants sont sujets du sultan, et que leurs champs, jusqu'à ce jour, sont sa propriété, il prélève un cinquième de la récolte et parfois davantage. L'Egypte est le seul pays du monde où la terre soit restée jusqu'aujourd'hui la propriété du monarque.

« Je ne parlerai pas de la grandeur du Caire ni de la multitude des hommes qu'on y voit circuler; beaucoup d'autres ont décrit cela, et tout ce qu'on a dit de la ville est vrai. La muraille qui entoure la ville n'est pas ininterrompue, bien qu'elle la protège en beaucoup d'endroits et de divers côtés. La ville est très animée et on y entend parler diverses langues par les étrangers qui l'habitent. Comme elle est située entre la mer Rouge et la Méditerranée, tous les marchands de l'Inde, de l'Ethiopie et du pays du Prêtre-Jean viennent au Caire par la mer Rouge, tant pour vendre leurs marchandises consistant en épices, perles et pierres précieuses, que pour acheter des articles provenant de France, d'Allemagne, d'Italie et de Turquie, amenés par la Méditerranée à Alexandrie et au Caire...

« Parmi les Juifs du Caire il y a des changeurs et des marchands, car le pays est grand, et certaines branches d'activité y sont ouvertes à tout le monde. Il n'est pas de marché plus favorable au commerce que le Caire. Il est facile de s'y enrichir, aussi y rencontre-t-on d'innombrables étrangers de toutes nationalités et parlant toutes sortes de langues.

« Au Caire on peut sortir la nuit aussi bien que le jour, car toutes les rues sont éclairées par des torches. Les habitants dorment par terre devant

[1] Nom hébreu de la « Fête des Sorts » qui rappelle le salut des Juifs obtenu par Esther. Elle se célèbre le 14 du mois d'Adar.

leurs boutiques. Le Juif peut acheter tout ce qui lui est nécessaire, viande, fromage, poisson, légumes, et généralement tout ce dont il a besoin, car on vend de tout dans la rue des Juifs. C'est le cas aussi à Palerme, mais il y a cette petite différence qu'au Caire les Juifs ne cuisinent à la maison que pour le sabbat; les autres jours ils se procurent leur nourriture toute préparée au marché, car les femmes aussi bien que les hommes sont occupées [au dehors] toute la semaine. Le bois est très cher au Caire : on paie plus de deux tiers de ducat, et davantage, pour une charge de bois moins grande que n'en porteraient deux mulets. La viande et les fruits y sont chers aussi, mais la viande y est très bonne, particulièrement la queue de mouton. Les Karaïtes [1] ne mangent pas de cette dernière viande parce que, selon eux, elle appartient à la catégorie des graisses que la *Tora* [2] interdit de manger. Je n'ai rien vu de bon marché au Caire, à part les oignons du Nil, les poireaux, les melons, les concombres et les légumes. Le pain y est à bon marché dans les années d'abondance; il est fait en forme de gâteau et pétri de manière à être très tendre.

« Avant de quitter le Caire, je suis allé au Vieux-Caire appelé *Mizraïm Atika,* lequel est également habité, mais par une population moins nombreuse que celle du nouveau Caire, dont il est très voisin. En route, nous vîmes l'endroit où le sultan fait élever tous les ans par ses hommes une digue contre la crue du Nil qui se produit au mois d'Ab. Au sujet de cette crue du Nil, j'ai entendu raconter bien des choses, mais il serait fastidieux de les rapporter, d'autant plus que je ne les ai pas vues de mes yeux. J'ai vu pleuvoir au Caire, mais pas beaucoup; et j'y ai connu des froids rigoureux à l'époque de Purim. En fait, les gens s'étonnaient de cette température et disaient qu'il n'avait pas fait aussi froid depuis bien des années. Et il est vrai que, selon tous les témoignages, l'Egypte est un pays très chaud.

« Il y a au Vieux-Caire une très belle synagogue bâtie sur des colonnes épaisses et magnifiques. Elle est dédiée au prophète Elie, qui, dit-on, y est apparu à des fidèles dans l'angle sud-est de l'édifice, où une lampe

[1] Secte juive qui rejette l'autorité des rabbins et se réclame du libre examen de l'Ecriture.

[2] La Loi, dans le Lévitique.

est entretenue en permanence. Dans l'angle nord-est, il y a une estrade où l'on plaçait le rouleau d'Ezra [1]. On raconte qu'il y a bien des années un Juif venu d'Occident acheta ce rouleau au serviteur du temple, et qu'il mit à la voile à Alexandrie, emportant avec lui le rouleau de la Loi. Mais il n'alla pas loin, car son bateau sombra non loin d'Alexandrie : lui-même périt et le rouleau fut perdu. Le serviteur du temple qui le lui avait vendu pour cent pièces d'or apostasia et mourut peu après. Le coffret du rouleau est toujours à la synagogue, et une lampe brûle en permanence devant lui. L'an dernier le sultan a voulu enlever pour son palais les colonnes de cette synagogue, car ces colonnes sont grandes et belles ; mais les Juifs les ont rachetées pour mille pièces d'or. D'après la date inscrite sur le mur de la synagogue, elle a été construite trente-huit ans avant la destruction du second Temple. Près de là se trouve une autre belle synagogue, mais qui n'égale pas la première ; des prières y sont offertes les jours de sabbat, et les Juifs y ont mis un gardien qu'ils paient».

FRANCESCO SURIANO (1494)

Né à Venise en 1450, d'une famille patricienne originaire de Syrie mais dont des membres firent partie du Grand Conseil de Venise dès 1300, Francesco Suriano fit en 1462, à douze ans, son premier voyage en Orient sur un navire appartenant à l'un de ses oncles. Il vit ainsi une première fois Alexandrie, où il devait revenir plus tard en qualité de vicaire apostolique pour l'Orient. Il fit dans la suite plusieurs autres voyages au Levant, notamment aux ports de Syrie ; puis, en 1475, il prit l'habit de franciscain et prononça ses vœux à Venise. Nommé Gardien du couvent de Beyrouth, il partit pour la Terre Sainte en 1481. En 1483, il est secrétaire du supérieur général de Terre Sainte au Mont-Sion de Jérusalem. Dix ans plus tard, en 1493, il est élu lui-même Supérieur Général de Terre Sainte et Vicaire apostolique pour tout l'Orient.

C'est l'année suivante, en 1494, que les devoirs de sa charge le conduisent au Caire : il y prêcha le carême et y passa tout l'été ; il y revint

[1] Le livre d'Esdras.

en 1503 pour la même mission. Lorsqu'en 1510, après une défaite navale infligée par les chevaliers de Rhodes au Sultan Khansou El-Ghouri dans les eaux de Jaffa, le sultan fit emprisonner les frères franciscains ainsi que les marchands vénitiens d'Egypte et de Palestine, Suriano fut deux ans en prison au Caire, jusqu'à l'arrivée de l'ambassadeur vénitien Domenico Trevisano en 1512. Il resta ensuite Gardien de Terre Sainte jusqu'en 1514, année où il rédigea son *Traité* au couvent du Mont-Sion de Jérusalem. Il finit sa vie en qualité de Gardien du monastère de Sainte-Marie-des-Anges près d'Assise, vers 1530.

Son ouvrage a été publié par le Père Jérôme Golubovich sous le titre suivant : *Il Trattato di Terra Santa e dell'Oriente di Frate Francesco Suriano, missionario e viaggiatore del secolo XV* (*Siria, Palestina, Arabia, Egitto, Abissinia, ecc.*), *edito per la prima volta nella sua integrità su due codici della Comunale di Perugia e sul testo Bindoni, dal P. Girolamo Golubovich, Ord. Min., missionario apostolico e figlio della Custodia di Terra Santa*. Milano, Tipografia editrice Artigianelli, 1900, in-8°.

Sa culture et son expérience n'empêchent pas l'auteur, qui a voyagé avec le détachement d'un religieux, d'admettre et de rapporter à l'occasion des informations naïvement exagérées. Voici la traduction de ce qu'il dit du Caire (aux chapitres 129-130, p. 178-181) :

« *Chap. 129. Des pèlerinages d'Egypte, et d'abord du Caire c'est-à-dire de Memphis, qui est Masar en arabe.*

« A l'intérieur et à l'extérieur du Caire il y a de nombreuses églises chrétiennes, parmi lesquelles l'église de Sainte Marie de la Colonne, où fut ensevelie Sainte Barbe.

« *Item,* une église faite presque entièrement en mosaïque, avec une crypte où la Madone a caché son Fils pour le protéger.

« *Item,* à l'extérieur et non loin de la ville, une petite chapelle où la Madone est demeurée quelques jours.

« *Item,* le fleuve du Nil qui sort du paradis terrestre.

« *Item,* la vigne d'Engadi, qui produit le baume et où se trouve un sycomore, sorte de figuier, au creux duquel la bienheureuse Vierge déposa Jésus.

« *Item,* sept pyramides, qui sont appelées vulgairement les greniers de Pharaon, ou de Saint Joseph.

« *Chap. 130. De la ville du Caire, dite en arabe Medinet el Massar, et des choses étonnantes et admirables qui s'y trouvent.*

« Notez que sous le nom du Caire on comprend trois villes, qui sont Babilone, Boulac et le Caire. Les deux premières sont sur la rive du Nil, mais la troisième est à six milles de distance du fleuve, et elle n'est pas entourée de murs, bien qu'en certains endroits se voient quelques pans de murailles antiques. C'est dans cette troisième ville que se trouve le siège et la résidence du sultan. Elle est à cent milles de distance environ de la Méditerranée.

« La ville est si grande qu'elle compte 16.000 paroisses [1], dont chacune a sa mosquée avec son minaret [2]. Toutes les rues de la ville, artères principales, ruelles et passages, sont fermées à clef toutes les nuits à la deuxième heure, et elles ne sont pas rouvertes avant l'aurore. C'est là une mesure efficace de sécurité au Caire, comme l'est chez nous l'usage de fermer au moyen de chaînes, en temps de trouble, les rues de la ville où sont les portes. Et c'est une des raisons pour lesquelles on ne vole pas la nuit au Caire, car le voleur surpris ne pourrait éviter l'arrestation.

« La ville a un château puissamment fortifié et très grand dans lequel demeure le sultan avec toute sa cour ainsi que sa garde composée de plus de 12.000 mameluks. Ce château a quatorze portes de fer, par lesquelles on passe quand on se rend à une audience du sultan. Ces portes ont des gardes en permanence. La garde de la dernière est confiée aux eunuques, en raison de leur fidélité et de leur loyauté plus grandes : leur honneur et leur réputation sont tels que tous les respectent, même les seigneurs et les émirs de mille lances.

« La ville a une population innombrable. Elle est riche en palais et en maisons qui sont plus belles à l'intérieur qu'à l'extérieur. Jusqu'à mi-hauteur, ces maisons construites en briques, qui sont des blocs quadrangulaires de limon du fleuve séché au soleil ; mais la moitié supérieure des maisons est faite de gravat lié avec de la boue, car là-bas on n'a pas de mortier. Ces maisons sont toutes découvertes, sans toit, car il ne

[1] *parochie,* dans le texte.

[2] *campanile,* dans le texte.

pleut jamais, hiver ni été, comme j'ai pu le constater pendant tout un été que je suis resté au Caire.

Contre la grande ardeur du soleil brûlant, les habitants ont deux moyens de se garantir : l'un est de tendre au moyen de chevilles une toile de tente qui ferme l'ouverture du toit quand le soleil, au milieu du jour, tombe d'aplomb dans les maisons découvertes ; et on laisse cette toile jusqu'à ce que le soleil baisse. L'autre moyen est de recevoir le vent marin, appelé *Provenza fresca,* qui règne durant dix mois de l'année : une bouche de dix brasses d'ouverture est construite en planches sur le sommet de la maison, et orientée de telle sorte que, d'où que le vent vienne, il est envoyé dans toutes les parties inférieures de l'habitation et la rafraîchit. Sans cela elle serait inhabitable.

« La ville a de belles rues, longues et larges. La principale, qui passe par le milieu de la ville, a trois milles de long et quinze brasses de large. De côté et d'autre de cette rue, il y a des boutiques et des magasins de marchandises, d'articles divers et d'approvisionnements. Toutes les victuailles coûtent cher, à cause du grand nombre de la population. Les concombres, les citrons, les courges et les fèves fraîches se trouvent toute l'année ; mais ils n'ont pas de raisins, ni de vin, sinon celui de Candie, qui coûte cinq ducats d'or le baril.

« La ville est très riche en argent et en marchandises. 16.000 chameaux sont employés à porter l'eau potable du Nil qu'on vend par le Caire. Et 20.000 chameaux transportent de tous côtés les marchandises. Il y a dans l'intérieur de la ville 40.000 moulins à grain, tous actionnés par des bêtes. A cause de la pénurie de bois, le pain se cuit au moyen d'un combustible fait avec du fumier de chameau pulvérisé qu'ils façonnent en forme de fouaces. 40.000 ânes sont utilisés dans la ville au transport des personnes ; ils sont harnachés de selles de soie et chacun est conduit par son ânier.

« Il y a en permanence dans la ville 24.000 mameluks, ou militaires, qui sont tous des chrétiens renégats. Ils gouvernent tout le pays et en sont les maîtres. Ils sont tous à la solde du sultan et payés tous les mois : en temps de paix ils reçoivent quatre ducats par mois, outre le pain, la viande et l'avoine pour leur cheval ; mais en temps de guerre ils reçoivent six ducats par mois, plus une allocation de cent ducats quand ils quittent

le Caire pour aller faire campagne. Au Caire ces mameluks sont convenables et leur attitude est réservée ; mais dans le pays, ce sont des démons déchaînés. Ils sont habiles au maniement des armes.

« Dans la ville, comme dans tout l'Orient, la peste sévit de sept en sept ans. Il meurt alors journellement au Caire de 12.000 à 25.000 personnes, et même il est des jours où le chiffre de la mortalité dépasse 80.000. La première année de ma charge de Gardien, 5.000.000 de personnes moururent dans la seule ville du Caire, à ce que m'a dit Tagribardi, le Grand Interprète du sultan. Et ces épidémies viennent de ce que la population ne prend pas de précautions : « Qui doit mourir, c'est écrit sur son front », disent-ils.

« Les céréales et le fromage se trouvent en abondance, mais non le bois. Ils cuisent les viandes au moyen d'une sorte de terre pétrie en blocs et qui brûle mieux que le bois : elle ne fait pas de flamme ni de fumée, mais s'échauffe à la manière du fer incandescent et conserve leur feu du matin jusqu'au soir ; une fois étouffé, il ne se ranime plus. Quelquefois ils rôtissent la viande et le poisson dans des plats au four. Ils font aussi du feu avec un mélange de fumier de bœuf et de paille.

« Ils ont des troupeaux d'oies, de canards et de poules, si nombreux qu'ils les mènent paître par la campagne comme du bétail. Les poussins n'éclosent pas comme chez nous par incubation sous les poules couveuses, mais à la chaleur du fumier ; et ils ont des fours où ils font éclore ainsi, quand ils le veulent, 100.000 poussins par jour. Et aux marchands qui viennent les acheter, on ne les vend pas à la centaine, mais à la mesure. Cette mesure est une sorte de demi-mine [1] sans fond : ils la remplissent de poussins, puis enlèvent la mesure ; les poussins restent sur le sol, et les acheteurs les mettent dans des cages.

« Le basilic se sème dans les campagnes comme généralement toutes les céréales ; et il croît jusqu'à hauteur d'homme. On s'en sert pour orner les sépultures : car la coutume est que, la nuit du vendredi, à minuit, ou tout au moins à l'aurore, les femmes vont veiller sur les tombeaux des morts, et elles apportent toutes de ce basilic et des fleurs de velours qu'elles disposent autour du tombeau en pleurant et en priant Dieu

[1] La mine équivalait à un demi-setier.

d'avoir les défunts en sa miséricorde et de diminuer leurs peines. . .

« L'endroit où est bâtie la ville est sablonneux et stérile, mais les céréales y sont amenées en abondance par le Nil, sur de grandes barques. Elles proviennent d'un pays situé à huit journées en amont du fleuve et appelé le Saïd [1]. C'est là que les Saints Pères Ermites faisaient pénitence. Il ne fournit pas seulement le Caire, mais encore toute l'Arabie jusqu'à la Mecque, et nourrit aussi bien les animaux, grands et petits, que la population, car il ne se trouve ni fourrage, ni herbe, ni aucune céréale dans tout le reste du pays. Tous les jours une caravane de chameaux part avec un chargement de blé qu'elle va vendre dans ces parties stériles ; et cette abondance est le fait du Nil ».

Au chapitre 131, l'auteur parle du Nil et de ses eaux, qui sont les plus fertilisantes et les plus saines du monde : cela vient, dit-il, de ce que le fleuve passe par l'Ethiopie sur un lit d'or fin. . .

Au chapitre 132, il nous conduit à Matarîya, au jardin des baumiers, qu'il trouve en fort mauvais état d'entretien ; et il nous parle de l'arbre de la Vierge, un « figuier de Pharaon ».

Enfin, avant de quitter le Caire, au chapitre 133, il décrit les pyramides de Gîza, dont il est l'un des premiers au moyen âge à avoir compris la vraie destination. Ce ne sont plus pour lui des « greniers de Pharaon », mais des sépultures. Il en a d'ailleurs vu extraire des momies. Il est monté au sommet de la plus grande de ces pyramides, et il a pénétré dans sa chambre funéraire où le sarcophage était en place. Ce qu'il nous dit au sujet de l'une d'elles intéresse la ville du Caire :

« La plus petite de ces pyramides a été démolie par l'émir Ezbeki [2] qui en a utilisé les pierres pour la construction de l'ensemble de l'Ezbekîya, laquelle occupe une enceinte de deux milles dans la ville [3] ».

[1] *che se chiama Sythi,* dit le texte.

[2] Général du sultan Kaït Bey et contemporain de l'auteur, qui combattit Bajazet Ier et captura son fils qu'il amena prisonnier au Caire. La mosquée qu'il construisit pour commémorer cette victoire n'existe plus depuis longtemps, mais le quartier où elle s'élevait a gardé le nom d'Ezbekîya.

[3] Le texte du manuscrit n° 58 de la Bibliothèque communale de Pérouse donne comme suit ce passage : « Le Seigneur Ezbeki a fait démolir un coin de ces greniers

ARNOLD VON HARFF, 1497

Le chevalier Arnold von Harff appartenait à une famille considérable du duché de Juliers et de Gueldre, et fut chambellan à titre héréditaire de la cour de Gueldre. Il naquit dans la terre de sa famille, à Harff sur l'Erft, près de Cologne, en 1471. Il posséda aussi, dans la même région, le château de Nierhoven, tout près de Lövenich, et c'est dans l'église de cette dernière petite ville qu'il reçut la sépulture en 1505. On pouvait y voir encore, avant la guerre de 1939-1945, son tombeau orné de trente-deux écus. Une notice biographique a été consacrée à Arnold von Harff dans l'*Allgemeine Deutsche Biographie*, par Wilhelm Heyd, l'auteur de l'Histoire du commerce du Levant au moyen âge.

A l'âge de vingt-cinq ans, en novembre 1496, il partit pour le long pèlerinage dont il nous a laissé la relation écrite dans son dialecte allemand du Bas-Rhin. Cette rédaction, dédiée au duc Guillaume de Juliers et à son épouse Sybille, semble avoir été très lue en son temps en Allemagne, car on en connaît une dizaine de manuscrits. Elle a été publiée pour la première fois par E. von Groote à Cologne en 1860 d'après trois manuscrits appartenant à la famille des Harff. Cette édition reproduit de nombreux dessins de la main de l'auteur [1]. Malcolm Letts en a donné une traduction anglaise avec de nombreuses notes et une introduction, en 1946 [2].

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et en a utilisé les pierres pour la construction de son palais et de nombreuses habitations dont l'ensemble peut équivaloir aux deux tiers de la ville de Foligno. Néanmoins le grenier (la pyramide) en question paraît à peine avoir été touché».

[1] *Die Pilgerfahrt des Ritters Arnold von Harff von Cöln durch Italien, Syrien, Aegypten, Arabien, Aethiopien, Nubien, Palästina, die Türkei, Franchreich und Spanien, wie er sie in den Jahren* 1496 *bis* 1499 *vollendet, beschrieben und durch Zeichnungen erlaütert hat. Nach den ältesten Handschriften und mit deren* 47 *Bildern in Holzschnitt herausgegeben von Dr.* E. VON GROOTE. CÖLN, J. M. Heberle (H. Lempertz), 1860, in 8°, LI + 280 pp.

[2] *The Pilgrimage of Arnold von Harff, Knight, from Cologne, through Italy, Syria, Egypt. . . Translated from the German and edited with notes and an introduction by Malcolm* LETTS, F. S. A., London, Hakluyt Society, 1946, in 8°, XXXV + 325 pp.

Arnold von Harff visita d'abord l'Italie. Il se trouva à Rome au printemps de 1497 et il fut reçu par le pape Alexandre VI. Il remonta ensuite vers Venise où il s'embarqua pour Alexandrie sur un bateau marchand, patron Andrea Lauredano. Après avoir caboté le long des côtes de l'Istrie et de la Dalmatie, le bateau toucha Candie, puis Rhodes, et arriva en vue d'Alexandrie. A trente milles du port, il fut abordé, comme c'était l'usage, par des émissaires du gouverneur de la ville, lesquels, montés à bord, envoyèrent aussitôt rapport à leur maître par le moyen de pigeons voyageurs.

Arnold von Harff, qui s'était déclaré marchand, paya deux ducats de droits de débarquement, au lieu qu'à titre de pèlerin il aurait eu à en payer cinq. Il passa quelques jours à Alexandrie, puis il fut s'embarquer à Rosette sur une petite barque du Nil à proue relevée que la langue du pays appelait, dit-il, une *schokarnia*. Le voyage jusqu'au Caire durait généralement cinq jours et coûtait un ducat. Par bon vent on naviguait à la voile, sinon on était halé à la cordelle par des chevaux.

Il ne nous dit pas la date de son arrivée au Caire, mais il nous dit celle de son départ : il a quitté la ville pour se rendre au Sinaï «le premier jour de la nouvelle lune». Cette nouvelle lune a dû être celle du début de juillet 1497.

On a beaucoup discuté de la véracité du chevalier Arnold von Harff, et il a eu dans son propre pays bien des détracteurs. Le fait est qu'il nous a conté beaucoup de fables et que, d'ailleurs, il lui a été matériellement impossible de visiter tous les pays qu'il nous décrit. Il n'a certainement pas eu le temps ni l'occasion de voir l'Inde ni l'Afrique centrale, pas plus qu'il n'a pu faire l'ascension des monts de la Lune ni découvrir les sources du Nil. Mais il a pu se servir, pour la description de pays inconnus, des relations de Marco Polo et de Jean de Mandeville qui commençaient à s'imprimer alors et dont on connaît plusieurs éditions allemandes de la fin du XV^e siècle. Arnold von Harff, dit Letts (*Introduction*, p. XVI), n'aura pas voulu décevoir ses compatriotes qui, sans doute, lui posaient mille questions sur le jardin d'Eden, les sources du Nil, le pays du Prêtre-Jean et les créatures étranges qui s'y rencontraient. Il avait d'ailleurs vu au Caire un ambassadeur d'Ethiopie qui lui avait parlé de son pays et de l'Inde. En tous cas, si la relation de Harff est

souvent naïve et crédule, elle présente malgré tout un caractère d'honnêteté que l'on sent et qui ne permet pas de considérer son auteur comme un vulgaire menteur. Et pour ce qu'elle dit du Caire, à part certaines exagérations manifestes, il n'y a aucune raison de la rejeter tout à fait, car l'auteur a réellement séjourné dans la ville et nous l'a décrite avec une sincérité et une franchise évidentes.

Il nous parle des mameluks et nous raconte les rivalités qui les divisèrent à la mort de Kaït Bey, les massacres qui s'ensuivirent, et la regrettable dévastation du jardin des baumiers à Matarîya, propriété du sultan.

Sa description du Caire commence par le château du sultan et par l'immense vue d'ensemble qu'on a du haut du Mokattam. Puis, c'est la ville avec ses innombrables rues et ruelles, sa population pittoresque et variée, ses cuisiniers ambulants, ses porteurs d'eau, ses riches marchands, ses établissements de bains, ses mosquées. Comme Piloti et tant d'autres, il nous parle du commerce des poules au Caire et des fours à couver les œufs. Il décrit les costumes des hommes et des femmes, et tente de nous donner une idée du chiffre de la population.

Nous traduisons cette description du Caire sur l'édition de Groote, p. 85 à 109.

« En abordant au Caire, nous dûmes, avant de pouvoir débarquer, envoyer chercher un guide auprès du Grand Interprète. Grâce à mon drogman qui connaissait le pays, nous eûmes ce guide sans trop attendre. En quittant le bateau nous dûmes passer par un poste de douane qui se trouvait sur le quai et où l'on inspecta tous nos sacs. Les marchandises furent frappées d'un droit de dix pour cent; chaque voyageur dut payer en outre deux ducats pour un permis; mais un pèlerin doit payer cinq ducats. Je passai pour marchand avec les autres, mais si ma qualité avait été découverte, j'y aurais perdu la vie et les biens.

« On nous conduisit à la maison du Grand Interprète où nous devions loger, et on nous alloua une chambre pour deux. C'étaient des trous comme des étables à cochons, où l'on ne trouvait que la terre sur laquelle nous devions dormir. Pour manger nous devions sortir dans les rues et nous acheter la nourriture nécessaire ainsi que de l'eau du Nil à boire. Cet interprète était un mameluk, c'est-à-dire un chrétien renégat, né à Gênes. Il avait dans sa maison quatre épouses légitimes.

« Le Caire est une très grande ville, pleine de population, mais sans murailles. Elle se divise en trois parties [1] : l'une est Babilone; l'autre, el-Kahira [2], et celle-ci a été anciennement entourée de murs, comme on peut le voir à des restes subsistant en certains endroits; la troisième est Masr [3].

« J'ai trouvé dans la ville deux mameluks allemands, l'un natif de Bâle et de son nom chrétien Conrad de Bâle, l'autre né au Danemark. Ils me témoignèrent tous deux une grande amitié et me menèrent à leur maison où nous bûmes secrètement du vin, comme nous le fîmes aussi parfois dans des maisons de juifs ou de chrétiens appelés là-bas Syriens; mais ce fut toujours dans l'intimité et en cachette, car les païens ne boivent pas de vin, mais seulement de l'eau. Les riches et ceux qui mènent grand train sucrent cette eau et l'aromatisent avec d'autres épices d'un grand prix. Les deux mameluks me conduisirent aussi par la ville pour me la faire visiter en détail. Pour commencer, ils m'obtinrent de leur maître le sultan un permis écrit pour traverser tous ses pays, la Syrie, l'Egypte, l'Arabie, la Terre Sainte, le royaume d'Alep et la Grande Arménie, ainsi que tous les autres pays sujets au sultan.

« Quand le sultan [4] apprit que j'étais arrivé de l'étranger, il me fit mander en sa présence et m'interrogea par l'intermédiaire de ces deux mameluks. Il voulait savoir si le roi de France était mon maître, quelle était sa puissance en hommes et armements, s'il avait conquis beaucoup de terres cette année et quels étaient ses projets. Je compris aussitôt la raison de cet interrogatoire, car j'avais entendu dire que tous les pays d'outremer étaient inquiets de ce que le roi Charles [5] de France avait conquis les années précédentes Naples, la Pouille et la Calabre, et qu'il voulait cette année marcher contre les païens et prendre la Terre Sainte; et j'avais effectivement constaté dans tous les pays païens et en Turquie une grande agitation et une grande crainte à ce sujet. Je répondis de manière à les satisfaire, mais moitié par des mensonges, car, après tout,

[1] *Elle a trois noms,* dit le texte.
[2] *Thayra,* dans le texte.
[3] *Maschera,* dans le texte.
[4] Mohamed, fils de Kaït Bey.
[5] Charles VIII.

je ne savais rien des affaires du roi de France. Je pris ainsi congé du sultan, et il me donna un sauf-conduit pour tous ses pays. Ce sauf-conduit me fut d'ailleurs de peu d'utilité, car de grandes rivalités divisaient le pays au sujet de ce sultan, jeune homme de seize ans à peine, qui était le fils du sultan précédent Kaït Bey, mort deux ans auparavant, et on n'avait pas beaucoup de considération pour lui.

« Il faut savoir que depuis le temps de Joseph vendu par ses frères en Egypte, il n'a plus jamais été de règle qu'un sultan fût de naissance païenne, mais toujours un chrétien renégat. Et c'est pourquoi le vieux sultan Kaït Bey avait régné en bon ordre sa vie durant. Mais, comme il était aimé de sa cour comme de ses sujets, il leur avait ordonné au moment de sa mort de faire son fils sultan après lui [1] ce qu'ils firent. Après la mort de son père, le fils occupa le château du Caire, qui est la résidence réservée aux sultans.

« Mais il se trouva un grand seigneur mameluk appelé Qansu Khamsmîya qui se déclara sultan en vertu du principe qu'aucun homme né païen ne peut devenir sultan. Il avait pour lui environ trois mille mameluks avec lesquels il mit le siège au château pendant trois jours [2], pour en chasser le jeune homme et prendre sa place. Le pays ne se mêla pas à la guerre, car elle n'était qu'une rivalité entre mameluks et leurs partisans. Après trois jours de siège au moyen de pièces d'artillerie légère — car ils n'ont pas d'artillerie lourde dans le pays —, au cours de la troisième nuit, le jeune sultan reçut secrètement dans le château un grand nombre d'hommes payés sur le trésor laissé par son père. Tôt matin ils opérèrent une sortie et tuèrent un grand nombre de gens de Qansu Khamsmîya, lequel s'enfuit vers une ville appelée Gaza. Mais au cours de sa fuite il tua au Caire tous les partisans du jeune sultan, et il se retira la première nuit près du Caire dans un village appelé Matarîya qui produit le baume dans un beau jardin appartenant au sultan. Ils arrachèrent les plants de baumiers, brisèrent les roues à eau qui servaient à l'arrosage du jardin et emmenèrent les bœufs qui les actionnaient, si bien qu'on me

[1] A l'âge de quatre-vingts ans, Kaït Bey avait abdiqué en faveur de son fils Mohamed qui devint sultan le 7 août 1496, à quatorze ans, et qui fut assassiné le 31 octobre 1498.

[2] Février 1497.

dit — et j'ai d'ailleurs pu le constater de mes yeux — que d'ici dix années le jardin ne produira plus de baume.

« Le jour suivant Qansu Khamsmîya se retira vers Gaza. En chemin par le désert [1] il fut rencontré par un autre grand seigneur mameluk appelé le Diudar [2] accompagné d'une nombreuse troupe. Celui-ci, de son côté, se préparait à marcher sur le Caire pour se faire sultan. Il savait que Qansu Khamsmîya avait tenté la chose pour lui-même sans y réussir. Ils en vinrent aux mains dès l'abord dans le désert, et ce Diudar tua Qansu Khamsmîya avec cinquante seigneurs et un grand nombre de ses gens. Il marcha ensuite sur le Caire et mit le siège au château du jeune sultan dans le but de s'emparer du pouvoir. La troisième nuit du siège, le jeune sultan reçut secrètement dans le château une nombreuse troupe. Tôt matin ils firent une sortie en petit nombre mais à grands cris et tuèrent beaucoup des gens du Diudar qui fut forcé à son tour de battre en retraite et de fuir vers Gaza.

« Mais un mois plus tard le Diudar avait réuni plus de vingt mille hommes, et il revint au Caire remettre le siège au Château pendant trois semaines durant lesquelles il donna l'assaut et livra bataille chaque jour. Cependant l'avantage resta au jeune sultan, et le Diudar dut prendre la fuite. Si le Diudar avait eu à sa disposition deux courtauds ou catapultes équipés à la manière de nos pays il lui eût suffi de deux jours pour mettre le château en pièces.

« Une fois le Diudar en fuite, les mameluks du jeune sultan firent irruption dans la ville, tuèrent tous ceux qui avaient été du Diudar et pillèrent toutes leurs maisons. C'est ainsi que le Grand Interprète chez qui je logeais et qui avait également été partisan du Diudar, vit sa maison détruite et ses biens confisqués. Ils détruisirent même ma chambre, où je me tenais caché, et ils s'assurèrent de moi avec force coups et bourrades et en faisant main basse sur tout ce que j'avais avec moi. Cependant ils me laissèrent aller après trois jours, lorsqu'ils surent que le jeune sultan m'avait donné un sauf-conduit. Mais les traitements peu chrétiens

[1] Dans le texte : *dat gewyltenysse Alhyset.*

[2] *Thodar,* dans le texte. Sans doute une corruption de *Diudar,* titre équivalent, d'après Ghistele, à celui de connétable en France.

qu'ils m'infligèrent pendant ces trois jours seraient bien longs à raconter, aussi les passerai-je sous silence. Voilà comment le jeune sultan, fils de Kaït Bey, maintint son pouvoir cette année-là ; mais j'ignore ce qu'il advint de lui par la suite.

« Les deux mameluks allemands me menèrent dans le château du sultan et me le firent bien visiter. Sa superficie dépasse, à mon avis, celle de la ville de Düren. Il est situé sur une élévation rocheuse, et l'on doit passer par douze portes avant d'arriver au palais proprement dit. A l'entrée de la première porte, à main droite, s'élève un grand bâtiment contenant de nombreuses salles où les jeunes mameluks suivent les leçons de trente-deux maîtres qui leur apprennent à lire, à écrire, à combattre avec la lance, à se couvrir du bouclier, à tirer à l'arc sur une cible et à s'exercer de toutes manières. J'ai aperçu dans ce bâtiment cinq cents jeunes mameluks, tous debout et les bras levés devant un mur comme s'ils s'apprêtaient à y grimper des mains et des pieds. J'ai demandé la raison de cette position bizarre, et on m'a répondu que c'était pour s'assouplir les bras et les membres.

« On passe ensuite par six autres portes, séparées par des intervalles où habitent des artisans de toutes sortes ainsi que les gens qui sont au service journalier du sultan.

« Passé la septième porte, nous vîmes à main gauche une fort belle mosquée, qui est une église à l'usage des païens, richement décorée. C'est là que le sultan et les grands seigneurs de sa cour offrent leur prière au Dieu du ciel et à Mahomet son prophète.

« La huitième porte nous donna accès sur une grande place carrée où tous les mameluks au service du sultan — au nombre d'environ seize mille à cette époque — devaient se rassembler trois jours par semaine au coucher du soleil. Là le sultan s'assied sur un siège élevé à hauteur d'homme et recouvert de riches tapis, sous une tente d'étoffes précieuses, les pieds repliés sous lui à la façon des tailleurs de chez nous sur leur table de travail. A ses côtés se tiennent debout ses deux officiers principaux : à droite l'Emir [1] et à gauche le Diudar [2]. Plus loin, d'autres membres

[1] *Armerigo,* dans le texte.

[2] *Thodar,* dans le texte.

de son conseil, tous hommes d'âge, gris, mais de belle apparence, appartenant au corps des mameluks. Le sultan siège trois fois par semaine de cette manière [1], donnant audience en présence de ses mameluks, car il veut que justice soit faite pour tous et que personne ne soit victime d'injustice.

« Nous passâmes ensuite la neuvième porte, où se trouvaient les écuries du sultan, contenant de bien beaux étalons.

« Puis nous passâmes par trois portes étroitement gardées, et nous arrivâmes à l'habitation personnelle du sultan, richement décorée.

« Après avoir contemplé ce palais, nous redescendîmes en ville. A la sortie, devant le château même, nous rencontrâmes plus de deux mille jeunes Mores à peau noire qui appartenaient tous au corps des mameluks. Je demandai aux deux mameluks allemands pourquoi ils se rendaient au palais avec leurs sacs et leurs coffres. Ils me répondirent ceci : Le sultan notre maître a actuellement 15.000 mameluks, chrétiens renégats, dont un millier ont été tués cette année. A ces mameluks il donne tous les mois six dinars ashrafi [2], soit six ducats. Il donne en outre à chaque mameluk dans le palais une ration quotidienne d'une livre de viande crue, de deux pains plats de froment et d'un setier d'orge pour son cheval. Les mameluks sont d'ailleurs payés régulièrement tous les mois. C'étaient leurs rations que ceux-ci venaient chercher.

« Nous vîmes aussi, sous les remparts du château vers le sud, une série d'arches de pierre venant du Nil et aboutissant au château. On m'expliqua qu'elles supportaient des conduits de plomb par lesquels l'eau du Nil était élevée industrieusement jusqu'au château.

« On me conduisit vers le sud-est sur une hauteur [3] d'où l'on se trouvait dominer le château et toute la ville. De cet endroit on pouvait se rendre compte de l'étendue de la ville et de sa disposition d'ensemble. Et l'on me dit que son pourtour était d'environ trente six milles français.

[1] Ici un dessin de l'auteur représentant le sultan assis sous un dais entre deux mameluks.

[2] *Six sheraphin,* dit le texte. Ce sont des dinars ashrafi, frappés par le sultan Barsbey (Al-Malik Al-Ashraf), 1422-1438.

[3] Le Moqattam.

De cette hauteur on voit aussi, vers le sud [1] le jardin de baume ainsi que le cours du Nil, et vers le sud-ouest un certain nombre de hautes constructions [2] dont trois sont appelées les « greniers de Pharaon » [3]. J'en parlerai plus loin. On voit d'ailleurs de là-haut presque tout le pays d'Egypte. On dit que cette montagne avec le château du sultan sont en Arabie, car le pays d'Arabie confine étroitement à la ville, qui est le pays d'Egypte.

« Ayant visité en détail cette grande ville du Caire avec les deux mameluks allemands, je parlerai ci-après de quelques-unes de ses curiosités merveilleuses. Elles paraîtront presque incroyables aux gens de nos pays.

« Le Caire a vingt-quatre mille rues et ruelles, dont vingt-quatre rues principales. L'une d'elles a plus de deux grands milles allemands de longueur; elle vient de Matarîya, où croît le baume, et elle traverse la ville et tout Babilone. Les autres sont moins longues et ont un mille et demi, un mille ou un demi-mille allemand. Sur les vingt-quatre mille rues il y en a beaucoup de très petites. Toutes les rues sont fermées à leurs deux bouts toutes les nuits par de hautes tours contre les incursions des mameluks. On évalue à quarante-huit mille peut-être le nombre des portes. Toutes les rues ont d'ailleurs un veilleur de nuit pour veiller aux incendies et aux tumultes. On estime à vingt-quatre mille peut-être le nombre de ces veilleurs préposés à la surveillance intérieure de la ville. Chaque rue a son cuisinier et ses deux boulangers désignés, de sorte qu'il y a dans la ville vingt-quatre mille cuisiniers et quarante-huit mille boulangers. Il existe, il est vrai, beaucoup de rues sans cuisinier ni boulanger, mais en revanche il y en a d'innombrables qui ont cent ou cent cinquante cuisiniers. Et il faut bien que les cuisiniers soient nombreux, car les païens cuisinent rarement à la maison. Quant aux boulangers, il en faut aussi un grand nombre, car le pain doit être mangé chaud au sortir du four, sans quoi la chaleur du soleil le durcirait comme pierre et le rendrait immangeable en moins de trois heures. Tous ces cuisiniers font la cuisine dans la rue. Plusieurs portent sur la tête par la

(1) C'est vers le nord que l'auteur aurait dû dire.

(2) *toerne*, dit le texte, c'est-à-dire des « tours ».

(3) Les *Cassa Faraonis*, dans le texte.

ville des fourneaux avec des poulets bouillis, des pois et d'autres nourritures cuites. Ils emploient tous de la fiente de chameau, car il y a très peu de bois dans le pays et il est importé de l'étranger, de Candie et de Chypre, et vendu à la livre. En Egypte ou en Arabie on ne trouve pas d'autre bois que celui du dattier, lequel ne convient pas du tout à la construction. Les cuisiniers débitent des poulets bouillis ou rôtis en grande quantité, et voici pourquoi : on dit par plaisanterie qu'il n'y a qu'un coq au Caire et qu'il a vingt-quatre poules. Chaque poule couve douze fois l'an et produit chaque fois trois ou quatre mille poussins. Et voilà ce qui explique qu'il y ait tant de poulets à manger — ce qui est un fait. Or le coq, c'est le sultan, et il a vingt-quatre poules, qui sont des fours à couver, avec quantité de trous ronds comme des coupes où l'on dépose les œufs. On recouvre toute la surface du four de fiente qui le bouche entièrement, et on allume en-dessous un feu très lent, si bien que ce feu, la fiente brûlante et l'air chaud du pays font éclore les œufs en trois semaines. J'ai vu nombre de ces fours dans des pays d'Europe, comme en Espagne, à Grenade et en Barbarie. Quand les poussins sont éclos, on les parque dans une petite cave voûtée où on les nourrit, puis on les vend. J'ai vu un marchand les vendre au setier : il les entassait dans le setier à pleines mains comme du froment qu'on mesure, de sorte que l'un des poulets avait la tête en l'air, l'autre une patte, l'autre les deux pattes, un autre une aile; et la mesure comptait tantôt vingt poulets, tantôt vingt-quatre. Ces cuisiniers préparent aussi couramment de la viande de chameau, laquelle est très agréable au goût, ainsi que beaucoup de viande de mouton, et ce sont des moutons aux larges queues et aux longues oreilles, comme sur la figure ci-contre [1].

« Les rues fréquentées de la ville ont besoin d'être arrosées d'eau trois fois par jour contre la grande chaleur et la poussière qui, sans cela, seraient suffocantes, car les rues ne sont pas pavées. Toute cette eau, et toute l'eau qu'on utilise dans les maisons pour le lavage et la boisson, est prise au Nil et apportée à dos de chameau. J'appris ce fait que plus de vingt mille chameaux sont employés uniquement à apporter toute la journée en ville, dans de grandes outres de peau de chèvre attachées à

(1) Ici un dessin de l'auteur.

leurs côtés, de l'eau puisée dans le Nil. Il y a en outre environ dix mille hommes qui portent sur le dos, à toute heure du jour, de l'eau du Nil dans des outres de peau de chèvre ; ils en donnent un gobelet pour une pièce de monnaie de cuivre, permettant ainsi aux gens de se désaltérer pendant les grandes chaleurs. De riches païens ont d'ailleurs établi par esprit de charité et pour l'amour de Dieu des points d'eau en beaucoup d'endroits des rues : ce sont de grands vases qu'on entretient pleins d'eau et où chrétiens, juifs et païens peuvent boire gratuitement. Sans cela beaucoup périraient suffoqués par la poussière et la grande chaleur.

« Les rues où l'on passe d'ordinaire sont pleines d'ânes, de chevaux, de chameaux et de mulets à louer. Ainsi hommes et femmes peuvent se faire transporter d'une maison et d'une rue à l'autre par la grande chaleur. Mais ni les chrétiens ni les juifs n'ont le droit d'être montés dans la ville. J'ai moi-même cependant chevauché par la ville en compagnie des deux mameluks allemands, mais c'est que j'étais habillé comme eux.

« Les maisons de la ville sont généralement très laides de l'extérieur et mal construites, mais l'intérieur en est fort beau, et elles sont toutes richement décorées d'or. Le sol même en est pavé de petits fragments de marbre précieux de toutes couleurs, qui s'entremêlent et dessinent de jolis sujets et des fleurs. On pourrait se mirer dans ce pavement. Le sol est d'ailleurs couvert de riches tapis qui sont des étoffes précieuses de soie travaillée. Aussi, quand on entre dans les maisons, doit-on enlever ses souliers ou ses pantoufles pour épargner la précieuse garniture du sol. Les gens vont alors s'asseoir sur les tapis à la manière des tailleurs de chez nous ; ils mangent et boivent, jouent et conversent ensemble, et tout cela sans grand bruit. Ils n'ont pas d'autre lit pour dormir que des tapis ; et plus on est riche, plus on en met dessous soi. Mais le commun du peuple dort sur le toit des maisons, couché sur des nattes, ou devant les maisons sur des planches. Hommes et femmes dorment ainsi de compagnie et sans se changer autrement qu'en mettant des chemises blanches.

« Leur religion permet de prendre six, dix, ou vingt femmes, autant que l'homme peut en nourrir. La loi veut que l'homme donne à chacune de ses femmes trois médines par jour (la médine est la vingt-sixième partie d'un ducat) pour le bain et pour le repas du soir. Le matin, elles doivent manger à sa table. Il doit en outre entretenir à leur service un esclave noir acheté. La règle est que si l'homme ne traite pas l'une de ses femmes comme il est dit, ou ne lui donne pas ce à quoi elle a droit, et qu'il veuille prendre plus de femmes qu'il n'en peut nourrir, elle peut, si elle le veut, porter plainte contre lui devant le juge et exposer les faits. L'homme est aussitôt battu, et la femme a le droit de se séparer de lui en emportant les biens qui sont à elle. Les femmes des pays païens jouissent d'ailleurs d'une immunité particulière, car, alors que partout dans les villes et les villages, hommes, vaches, ânes, chevaux et toutes les espèces d'animaux ainsi que toutes les marchandises sont soumis à des taxes et à des péages, les femmes en sont exemptes. Un homme du commun n'a qu'une femme ; et celui qui en a dix ou douze doit éviter qu'il ne s'élève des disputes entre elles. Mais la chose s'entend rarement, et c'est ce qui me surprend beaucoup.

« Au Caire un nombre incroyable de gens habitent la même maison, parfois dix ou douze familles. Il y a dans la ville trente mille chrétiens recensés de toutes confessions, sans compter les Latins. Il y a aussi dix mille juifs recensés qui doivent payer par tête, annuellement, trois ducats au sultan. Ces chrétiens sont des Grecs, des Jacobites, des Syriens ; ils ont dans la ville un patriarche et lui obéissent dans les affaires spirituelles comme nous au pape de Rome. Chaque communauté chrétienne ou juive a dans la ville sa propre rue, et elle est fermée sur eux la nuit. Il y a au Caire des chrétiens et des juifs très riches qui possèdent trente ou quarante mille ducats. On reconnaît les chrétiens, les païens, les turcs et les juifs à leur costume, tel qu'il est représenté ci-contre [1] : le chrétien porte enroulé autour de la tête un long linge bleu ; le païen, un long linge blanc enroulé autour d'un couvre-chef plat et raide ; le turc porte sur la tête un haut bonnet pointu autour duquel s'enroule un long linge blanc ; et les juifs portent autour de la tête un long linge jaune. C'est par là qu'on reconnaît dans la ville ces quatre nations, comme le montre l'image.

« Il m'a été affirmé qu'un marchand de condition moyenne établi au Caire possède couramment trente ou quarante mille ducats, mais que beaucoup des plus riches en possèdent plus de deux cents mille. Cela

[1] Ici un dessin de l'auteur.

paraît incroyable, mais c'est vrai, car, de tout l'argent, monnayé ou non, qui se trouve dans nos pays, il s'en exporte tous les ans la valeur de trois cents mille ducats dans les pays païens, et ceux-ci ne nous envoient pas d'argent en échange, mais des épices et des étoffes de soie. Ils ont, au surplus, beaucoup d'argent et d'or qu'ils trouvent dans le sable. J'en parlerai encore plus loin, mais je pourrais instruire bien mieux le lecteur sur ce point si je pouvais l'entretenir de vive voix.

« Dans la ville du Caire il existe un grand nombre d'établissements de bains chauds, richement et confortablement installés, pour hommes et pour femmes séparément. On y passe par trois ou quatre petites salles de plus en plus chaudes avant de pénétrer dans la salle principale. Ces salles sont entièrement revêtues de marbre, sol et parois. Toutes sont portées à température par l'eau chauffée à la fiente de chameau dans de grands vaisseaux à l'extérieur des bains. Cette eau est conduite par des tuyaux dans les salles, où elle tombe dans une série de belles vasques de marbre. On peut s'y plonger et y prendre son bain à son gré. C'est la vapeur d'eau qui chauffe ces salles. Il y a là d'habiles garçons de bains qui vous couchent, vous retournent et vous étirent tous les membres pour les assouplir ; et c'est la raison pour laquelle les gens sont plus souples et plus alertes dans ce pays que chez nous. De plus ces salles de bains ont des voûtes formées de carreaux de verre arrondis, si bien qu'il y fait aussi clair que dans la rue.

« Il pleut très rarement au Caire et dans les régions environnantes d'Egypte et d'Arabie. La pluie, le tonnerre, la grêle et les éclairs y sont pratiquement inconnus, et l'on voit rarement passer des nuages dans le ciel, mais la chaleur est toujours grande. . .

« . . . Les nuits ne sont jamais de plus de neuf heures ; aussi les jours de la Saint-Jean sont-ils moins longs que dans nos pays. Je n'en expliquerai pas ici la raison, car le commun ne la comprendrait pas. J'avais toujours avec moi un astrolabe pour mesurer la hauteur du soleil, de la lune, des étoiles et de l'arc céleste partout où j'étais en pays étranger.

« Vers le milieu de la longue rue du Caire qui mène au palais et, peut-on dire, à peu près au centre de la ville, s'élève une porte haute et belle, solidement maçonnée et flanquée de deux tours, et sous laquelle

on passe [1]. Lorsqu'un seigneur ou un mameluk s'est rendu coupable d'un crime, on le pend entre ces deux tours à la vue de tous.

« Disons un mot de la religion. Les Mores, qui sont appelés Païens ou Sarrazins, ont grandement la crainte de Dieu. Jeunes et vieux, ils prient contre le sol cinq fois par jour dans la direction de l'Orient, en baisant le sol avec révérence et en disant : Allah Karîm. . . Leur jour de repos est le vendredi, et chacun va à la mosquée pour prier. A l'entrée des mosquées il y a généralement des fontaines : ils s'y asseoient et lavent les membres avec lesquels ils ont péché la nuit ou le jour ; sans cela ils s'estimeraient indignes de prier Dieu. Après quoi ils s'accroupissent sur des nattes et des tapis, les pieds repliés sous eux à la manière des tailleurs de chez nous, et ils prient avec beaucoup de dévotion en baisant le sol à maintes reprises. Les prêtres sont accroupis de la même manière en un endroit surélevé dans la direction de l'Orient, et ils chantent leurs offices dans la langue more ou païenne, aux consonnances étranges. Ils sont curieusement habillés de blanc, avec de hauts bonnets pointus. A la fin, ils montrent une lettre à laquelle ils témoignent une grande révérence en se courbant jusqu'à terre : on dit que cette lettre contient les dix commandements reçus par Moïse sur le mont Oreb.

« Les mosquées, qui sont leurs églises, n'ont absolument aucune image, aucune idole de bois ou de pierre, aucune représentation peinte. Mais un très grand nombre de lampes y brûlent en l'honneur de Dieu, tant à l'extérieur qu'à l'intérieur. On m'a assuré que la ville du Caire possède trente six mille mosquées ou églises païennes, et j'en ai compté moi-même le plus grand nombre. Elles sont grandes et belles, ces églises, avec un chœur et une ou deux hautes tours décorées de sculptures et agrémentées de deux ou trois balcons superposés. Les prêtres y montent cinq fois le jour pour crier l'heure et annoncer les offices, car il n'y a pas de cloches. Ces prêtres disent les offices dans les mosquées cinq fois par jour. Ils n'ont pas de revenus personnels, mais vivent de ce que les gens leur donnent par piété quand ils vont chantant par les rues. Ces prêtres ont aussi leurs écoles, où ils apprennent aux enfants à lire et à écrire en

[1] La Bâb Ez-Zuweila.

langue moresque. Au sommet des tours de leurs mosquées il y a généralement un croissant en plomb ou en fer.

« Les cimetières sont tous éloignés de la mosquée et en dehors de la ville. Quand quelqu'un est mort, ses amis l'habillent de ses meilleurs vêtements et l'asseyent sur une chaise faite pour cet usage. Son plus proche parent s'approche alors et lui colle sur la joue une pièce de monnaie. Tous ses amis les plus intimes en font ensuite de même tout en chantant. Puis les prêtres prennent le corps et le déposent dans une bière élevée, ils prennent l'argent des joues du mort et emportent celui-ci, vêtu de ses beaux habits et le visage découvert, par les rues vers leur cimetière. Les femmes et les intimes du mort suivent la bière en criant et en se lamentant à haute voix, s'arrachant les cheveux et jetant sur leur visage de la poussière et de la boue des rues. On arrive ainsi au cimetière, où les prêtres prennent le corps en chantant et le déposent en terre. Ils ont préparé un encens précieux qu'ils allument et laissent brûler sur la tombe. Les prêtres et les parents du mort se prennent ensuite par la main et dansent autour de la tombe en chantant à haute voix dans leur langue : ils disent qu'ils livrent l'âme du mort avec la fumée précieuse à leur prophète Mahomet, le priant de vouloir la recommander à Dieu dans le ciel. La femme du mort reste couchée sur la tombe en pleurant jusqu'au troisième jour; ses proches parents viennent alors la chercher et l'emmènent. Ils portent tous des vêtements de deuil blancs comme neige.

« Les sultans ont bâti à l'extérieur de la ville des mosquées très riches et très belles, qu'ils ont dotées et ornées, et qui leur sert de sépulture [1]. Dans l'une d'elles plus de cent lampes brûlent en permanence».

Harff nous dit ensuite que les musulmans ne boivent pas de vin, qu'ils observent le vendredi au lieu du dimanche et qu'ils jeûnent pendant le mois de Ramadan.

Il a vu des éléphants au Caire, des lionceaux et des girafes. Il nous décrit naïvement ce dernier animal qui lui paraît plus extraordinaire encore que les autres.

[1] Ce sont les monuments dits : «les tombeaux des mameluks», à l'est de la ville.

Puis il parle du sultan Kaït Bey, mort deux ans auparavant, et nous raconte que c'était un ancien berger circassien vendu comme esclave au Caire et devenu mameluk. Il est ainsi amené à parler des mameluks, dont il décrit le costume :

« Le mameluk porte une longue robe de lin ajustée qui lui tombe jusqu'aux pieds. Il marche pieds nus dans de hautes sandales de bois, à cause de la chaleur du sable, et il porte sur la tête un bonnet rouge haut de trois empans auquel s'enroule et pend une longue écharpe de laine large d'un empan. Mais certains grands seigneurs mameluks portent enroulés autour de la tête de longs linges blancs, comme le montre la figure [1].

« Quand ils marchent ou chevauchent par les rues, ils portent toujours à la main un grand bâton, et une épée au côté, et tout le monde doit leur faire place. . . Ils ont de très beaux chevaux et étalons qui couchent sur le sable sans paille ni foin. . .»

Voici maintenant le costume des femmes :

« . . . Les femmes du Caire et du pays sont gardées très étroitement par leurs hommes. Quand elles marchent ou chevauchent par les rues, elles portent toujours sur le visage des voiles noirs, de manière qu'on ne les reconnaît pas. Mais elles se connaissent entre elles, et sont toutes habillées de même, d'une robe blanche; seul le voile qui cache leur visage est noir. . . Partout dans les rues il y a des postes d'ânes et de mulets de louage : elles s'y asseyent et vont ainsi montées à côté de leurs hommes, si bien dissimulées que leurs propres maris ne les reconnaissent pas. . .

« Il y a de grandes différences entre les usages du pays et les nôtres. Par exemple, les femmes portent des pantalons de peau avec des jupes, et les hommes vont pieds nus. D'autre part les hommes portent des turbans autour de la tête, mais non les femmes. Celles-ci portent sur la tête une haute coiffure qui ressemble à un pot, entouré d'un linge fin

[1] Ici un dessin de l'auteur.

et d'ornements, et elles vont montées ou à pied comme le montre cette figure [1]».

Sans transition, l'auteur nous dit ensuite comment on traite les voleurs au Caire :

« Les voleurs surpris au Caire ne sont pas pendus. Ils sont attachés, trois ou quatre ensemble, avec des chaînes de fer et livrés à un païen qui en a la garde. Chacun d'eux est tenu de payer deux ou trois médines par jour au sultan, sans quoi ils sont sévèrement battus le soir par leurs gardiens, Pour se procurer cet argent pour le soir, ils circulent en ville pendant le jour, gênés par leurs chaînes, et mendient pour l'amour de Dieu ; ils volent d'ailleurs autant de fois que l'occasion s'en présente, afin d'échapper au châtiment du soir. On m'a affirmé que dans la ville du Caire circulent plus de dix mille voleurs ainsi enchaînés».

Harff essaie de nous donner une idée du chiffre de la population du Caire :

« La population n'est ni dénombrée ni recensée. Je suis convaincu qu'elle est plus nombreuse que celle des deux villes de Cologne et de Trèves réunies. Je vous ai donné plus haut le nombre de personnes de certaines catégories qu'on peut dénombrer, notamment les cuisiniers, qui sont au nombre de 24.000, les boulangers, 48.000, et les porteurs d'eau, 30.000, qui apportent journellement l'eau du Nil à boire. Qu'on songe au nombre de personnes devant consommer tout cela.

« On compte en outre 16.000 mameluks, et chacun d'eux a au moins un serviteur. En fait, très nombreux sont les mameluks qui ont trente ou quarante serviteurs ; et beaucoup des principaux seigneurs en ont deux ou trois cents.

« On compte dans la ville 30.000 ménages chrétiens et plus de 10.000 ménages juifs, avec femmes, domestiques et enfants. Il y a d'ailleurs 36.000 mosquées, ou églises, chacune avec deux ministres de la religion, en moyenne. Tout ce monde ensemble, sans compter les serviteurs des mameluks et leurs femmes, fait approximativement 300.000 personnes. Et il faut ajouter à ce nombre la multitude des femmes, des enfants,

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[1] Ici un dessin de l'auteur.

des serviteurs, hommes et femmes, des bourgeois du commun, des marchands et des fonctionnaires, avec leurs femmes, leurs enfants et leurs serviteurs des deux sexes».

L'auteur passe par le Vieux-Caire pour aller aux Pyramides ; il nous dit un mot des églises de Babilone :

« Les deux mameluks me conduisirent de l'autre côté du Nil aux trois greniers de Pharaon [1] situés à cinq milles allemands environ de la ville du Caire. Pour y arriver il faut faire un grand détour à cause de la courbe du Nil. Partis de notre auberge, nous commençâmes par remonter la rive du Nil en traversant la ville de Babilone. Là, nous arrivâmes d'abord à l'église appelée Saint-Georges, qui appartient aux chrétiens géorgiens. On me dit que c'était l'endroit où la Sainte Vierge avait vécu pendant sept années avec Notre Seigneur Jésus et Joseph lorsqu'ils se furent enfuis de la Terre Promise en Egypte. Non loin de là nous allâmes visiter quatre autres églises chrétiennes dans lesquelles on nous montra beaucoup de choses vénérées selon les sectes».

Harff décrit ensuite la masse des pyramides. Elles passent, dit-il, pour être les rombeaux des anciens rois d'Egypte ; mais il n'a pu en découvrir l'entrée.

Puis il décrit le jardin de Matarîya où les deux mameluks le conduisirent le lendemain et qu'il trouva complètement dévasté : nombre de petits arbustes, de la longueur d'un bras, gisaient arrachés sur le sol, et le jardin, dit Harff, ne produira plus de baume avant dix ans.

Il donne ensuite un vocabulaire arabe-allemand de mots courants et reproduit un alphabet arabe de trente et un signes. Il nous dit enfin comment il se prépare à quitter le Caire pour le Sinaï en compagnie d'un ambassadeur du souverain de l'Inde, alors de passage au Caire et qu'il a rencontré au palais du sultan.

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[1] *Kassa Pharaonis,* dans le texte.

PHYSICAL ELEMENTS
OF AGRICULTURAL LAND USE
IN THE FAYUM DEPRESSION

BY

D^R MOHAMED IBRAHIM HASSAN

The purpose of this paper is to study the physical elements which have had a radical effect on the land use and agricultural economy of the Fayum Depression. These elements are : terrain, soils, and water supply.

The Fayum Province, which has an area of about 2.000 square kilometres, is a large circular depression in the Libyan desert situated west of that part of the Nile Valley lying between el Ayat and Feshn.

The Fayum is quite unique among the provinces of Egypt as in spite of the fact that its lands are watered by direct flow from the Nile like those of the Nile Valley and delta, its drainage does not pass back into the river or into the Mediterranean, but into lake Qarûn which lies in the lowest part of the province and which is 45 metres below sea-level. This province occupies a deep depression in the limestone plateau of the Libyan desert with an access to the Nile Valley. It is thus considered like the other oases and depressions of the Libyan desert in the fact that they are all deprived of drainage outlet, and it is also considered a part of the Nile Valley like the other provinces which are watered by the river. This double affinity gives a very special interest to the study of the land use of the Fayum depression.

I. TERRAIN

The excavation of the Fayum depression was accomplished by wind erosion in early Pleistocene times. Two special causes have acted in its production : A) The presence of thick bands of comparatively soft arenaceous and argillaceous strata breaking up the usually continuous hard limestone of the middle Eocene ; B) Apart from the presence of sediments varying greatly in hardness and durability, the fact that the whole of the rocks have almost constant northerly dip of two or three degrees is a point of prime importance [1]. The origin of the Fayum depression is similar to that of the other great hollows of the Libyan plateau such as the oases of Kharga, Dakhla, Baharia and the Qattara depression, which are devoid of any drainage outlet either to the Nile or to the sea.

From the physical stand point, the area under study is primarily divisible into two distinct parts : A) the lake ; B) the depression floor.

A) *The lake :* Birket Qarûn, a shallow brackish lake, occupies the lowest part of the depression. The lake, which has a length of 40 kilometres and a maximum breadth under ten, covers at the present time an area of about 200 square kilometres and lies about 45 metres below sea-level. The lake undergoes fluctuation in its level from year to year due to variations in the rate of influx of drainage water into it, and in the rate at which evaporation takes place from its surface. The magnitude of these oscillations depends mainly on variations in the available Nile supply in different years, and on the degree of artificial control on the flow of Nile water into the depression. Resultant upon carefully maintained control on Nile water in Fayum, the amplitude of the annual oscillation of

[1] Beadnell (H. L.), *The topography and Geology of the Fayum Province of Egypt,* Cairo, 1905, pp. 15-16 ; Caton-Thompson and Gardner, *Recent work on the problem of lake Mœris, Geographical journal,* London, january, 1929, pp. 20-60 ; Sandford (K.) and Arkell, *Paleolithic man and the Nile-Fayum Divide, University of Chicago press,* 1929 ; Ball (J.), *Contributions to the geography of Egypt,* Cairo, 1939, pp. 189-190.

the lake-level averages only about 70 centimetres [1] and the mean level of the lake in any year does not depart by more than 50 centimetres from the average of 45.5 metres below sea.

The following table shows the areas and volumes of the birket Qarûn at different levels.

[2] Level, in metres below sea	Area, square kilometres	Volume, millions of cubic metres	Level, in metres below sea	Area, square kilometres	Volume, millions of cubic metres
44.0	237.7	1028	45.6	199.9	678
44.1	235.4	1004	45.7	197.5	658
44.2	233.1	981	45.8	195.0	638
44.3	230.7	958	45.9	192.6	619
44.4	228.4	935	46.0	190.2	600
44.5	226.1	912	46.1	187.8	581
44.6	223.8	890	46.2	185.4	562
44.7	221.5	868	46.3	183.0	544
44.8	219.2	846	46.4	180.6	526
44.9	216.8	824	46.5	178.2	508
45.0	214.4	802	46.6	175.7	490
45.1	212.0	781	46.7	173.3	473
45.2	209.6	760	46.8	170.9	456
45.3	207.1	739	46.9	168.5	439
45.4	204.7	719	47.0	166.0	422
45.5	202.3	698			

Resulting upon the shallowness of the lake, it is noticed from the above table that the area and volume both diminish rapidly as the surface-level falls. 53 metres below sea-level is the lowest point of the bed of the lake, while the level of the surface at the present day averages about 45.4 metres below sea with a seasonal range of about 35 centimetres above and below this mean level. From the land use point of view, the figures in the table help to explain a remarkable fact, that approximately half the total volume of water in the lake disappears each year mainly by evaporation and is replaced by a corresponding inflex of drainage water. To translate this important inference into figures, it is noticed that the average volume of the lake at its present day level of 45.4 metres below

[1] Ibrahim Rakshy, *Irrigation and drainage of Fayum Province,* pp. 62-64. (*The Engineers' Magazine,* july-august, 1947) [in arabic].

[2] Ball, *op. cit.,* p. 237.

sea is about 719 million cubic metres, while the average volume of drainage water annually passing into the lake amounts to about 365 million cubic metres; and as the mean level of the lake remains nearly constant from year to year, it follows that a like quantity of about 365 million cubic metres must annually be removed mainly by evaporation [1].

This conclusion means that the total area of land that can be cultivated in the Fayum is definitely limited by natural conditions. In other words, if the total area of land now irrigated in the Fayum, which is about 310,678 feddans [2], were to be increased by five per cent, without at the same time diminishing either the average quantity of irrigation water annually supplied to each feddan or the quantity of drainage water annually discharged from it, the total annual influx of drainage water into the lake would likewise be increased by five per cent; and this rise of the lake level would have the effect of submerging or waterlogging an area of land around the lake at least equal to that of the land that could be newly brought under cultivation elsewhere in the province. Moreover the construction of an embankment round the southern shore of the lake would not improve the situation, as it would cause a rise in the level of the lake and it would certainly cause a corresponding rise in the subsoil water-level of the lands bordering it, and thus hinder the efficient drainage of those lands.

B) *The Depression Floor :* The remaining 1700 square kilometres is occupied by the depression floor which slopes downwards in a north-westerly direction from a level of about 23 metres above sea to the lake, and consits mostly of rich alluvial land irrigated by canals that enter the depression from the Nile by way of a narrow opening through the desert hills [3]. The depression is bounded by a great undulating high-lying

(1) BALL, *op. cit.*, p. 238.

(2) Département de la statistique et du Recensement, *Annuaire statistique*, 1949, Le Caire, 1952, p. 339. — A feddan is 4.200.833 square metres — a square kilometre = 238.05 feddans

(3) *Map of the Nile Delta and Fayum Depression*, scale 1 : 300.000, published by the Survey of Egypt, 1936; BROWN (H.), *The Fayum and lake Mœris*, London, 1892, pp. 19-22 and p. 95.

gravelly desert-plateau which stretches with little change of character to the Mediterranean.

To the north and north-west of lake Qarûn, the ground rises rapidly in a series of escarpments to the summit of the rim of the depression, averaging 340 metres above sea-level. The uppermost escarpment, well known by the name of Jebel el Qatrani, is formed of sandstone and clay, and capped for a distance of many kilometres by a thick bed of hard black basalt. Northwards from Jebel el Qatrani, stretches a rolling pebbly desert, the monotony of which is only relieved by the occasional belts of sand that run in straight lines and in a N. N.W.-S. S. E. direction.

To the east, there is a desert ridge separating the Nile valley from the Fayum. To the north of Bahr Yusef, the ridge has an average width of some ten kilometres; further south it narrows until due east of Gharaq the ridge is about 2 ½ kilometres wide. The highest points of this ridge attain altitudes of over 100 metres above the cultivated land below. From these summits, the slope is gradual to the Nile Valley and more rapid towards the Fayum. The ridge is cut down to a comparatively low level in several localities, mainly to the north-east of Tamiya where a road runs from the Nile Valley to the depression, to the south-east of Maṭar Tares where the railway crosses, and at the opening where Bahr Yusef canal enters [1].

To the west, a limestone dividing ridge separates the Rayan depression from the cultivated lands of Gharaq and Fayum. The ridge is generally from 30 to 60 metres above sea level with an average width of 15 kilometres [2].

A remarkable feature of the desert, which surrounds the Fayum depression, is the abundance of sand dunes from which the prevailing winds carry the weathered matter in suspension and dump it at the foot of the escarpment. This wind-born sand is the scourge of cultivation at the edge of the depression, and to irrigation and drainage channels for it

(1) *Map of Fayum Province*, 1 : 100.000; published by the Survey of Egypt, 1929.

(2) AWAD (M.), *The Nile*, p. 131 (in arabic).

chokes them [1]. Affected zones are generally in the direction of the northern prevailing wind, and are located near stretches of dry desert sand devoid of grass or shrubs to the windward. Such zones are usually protected by patches of trees.

During many trips of the writer in several parts of the depression, one special fact forced itself upon the attention, namely, that throughout the Fayum the low lands are invariably sacrificed to the high. Areas covered with efflorescences and soils which are too bad for any cultivation or give only the poorest of crops, are generally below the surrounding fields. The cause of the injury is the drainage from the adjacent and higher ground, which carries with it an excess of injurious salts to the lower ground. Over-irrigation without corresponding drainage accentuates the evil.

II. SOILS

A) The clay soil :

The depression floor is mainly covered with alluvial soil which is mostly identical in origin and composition with the river-alluvium of the Nile Valley [2]. Acording to Ball, the first ingress of Nile water into the depression took place in the Acheulean period, roughly perhaps some 70,000 years or so ago [3]. This alluvium has been accumulated to considerable thickness as Bahr Yusef, for thousands of years, has annually overflowed its banks and deposited suspended matter on its plains. According to Fayum contours, alluvial deposits cover a leaf-shaped tract between the bounding desert and the lake. In other words, they form a delta spreading out fan-wise from the point where the Nile-water enters the depression. A boring made for obtaining underground water at Madinet el Fayum by the Public Works Department in 1898 passed first through a thickness of about 5 metres of Nile mud, then through 1 ½ metres of mixed mud and sand, and finally through 12 metres of sands

[1] Shafei (A.), *Protection against wind blown sand* (*Bulletin de la Société de Géographie d'Egypte*, t. XXV, mars 1953, pp. 71-75.

[2] Beadnell, *op. cit.*, p. 11.

[3] Ball, *op. cit.*, p. 190.

and gravels, before reaching Eocene marls and limestones that form the true rock-floor of the depression [1]. Attention should be drawn to the fact that Madinet el Fayum lies at the head of that lake delta, and so the average thickness of Nile mud and of the underlying layers over the Fayum as a whole are considered less than at that particular place. For comparison, the average thickness of the Nile mud is about 9.8 metres in the Delta and 8.3 metres in the Nile Valley between Aswan and Cairo [2].

Derived mainly from the decomposition of volcanic rocks of the Abyssinian plateau due to heavy summer rains and torrents that feed the Blue Nile and Atbara, and carried for a long journey to the lower Nile Valley and Fayum depression, this soil has a great variety of salts and minerals necessary to plant life with the exception of nitrates [3]. The deficiency of nitrogenous compounds is remedied by a rotation of beans, lentils, and clover, and by use of Chilian nitrates [4].

Differences of composition, as shown from the following table, are relatively small between the cultivated soil and the suspended matter of the river in flood.

	[5] Suspended matter of the river in flood	Cultivable soil
Silica and insoluble matter	57.54 %	60.12 %
Ferric oxide and alumina	25.56	22.14
Manganese oxide	0.25	0.26

Cont. Table on page 58

[1] Beadnell, *op. cit.*, p. 29 ; Ball, *op. cit.*, p. 35 ; *Public Works Ministry report*, Cairo, 1899.

[2] Mohamed Ibrahim Hassan, *Physical Elements of Agricultural Land Use in the Nile Delta* (extrait du *Bulletin de la Société de Géographie d'Egypte*, t. XXVI, août, 1953, p. 231).

[3] Xilinas, *Le Nil, son limon et la terre égyptienne*. Cairo, 1936, p. 13.

[4] Moustafa Amer, *Some problems of the population of Egypt* (*annexes to the report of the Egyptian Delegates to the Geographical Congress*, Cambridge, 1928, p. 3).

[5] Ball, *op. cit.*, p. 164 ; Mackenzie, *The Nile in relation to Egyptian agriculture*, year book of the Khedivial Agricultural Society for 1905, p. 239 ; Foadan and Fletcher, *Text book of Egyptian agriculture*, Cairo, 1908, p. 226-227 ; Hussein Kamel Selim, *Twenty years of Agricultural Development in Egypt*, 1919-1939, p. 10.

	Suspended matter of the river in flood	Cultivable soil
Lime	3.07 °/o	4.19 °/o
Magnesia	2.68	2.70
Potash	0.53	0.62
Soda	0.57	0.64
Carbonic anhydride	0.73	1.47
Sulphuric anhydride	—	—
Phosphoric anhydride	0.25	0.25
Chlorine	—	0.06
Organic matter	8.82	7.55

The above table indicates that the clay soil is quite rich in silica and ferric oxide, less rich in Potash and magnesia, and poor in nitrogenous compounds.

Physical constitution of this soil varies greatly as some localities have finer deposits than others. « Safra » or yellow soil with about 20 % of clay prevails near Bahr Yusef and the other canals, while « Soda » or black soil with 50 % to 60 % of clay predominates between them. This variety in soil composition and structure is mainly due to the fact that heavy sand particles tend to be deposited first and the rate of deposition varies according to the velocity of the current. Such variety in soil structure is strengthened by three major factors, namely, varying heights of summer floods, Bahr Yusef traverse in the desert, and abundance of sand dunes in the neighbouring desert where prevailing winds carry sand to the depression.

Not all the alluvial soil of the depression is cultivated, as large areas around lake Qarun in the northwest and around marshes of Gharaq basin in the southwest, remain untilled and saturated with salt. Many factors are responsible for the existence of such waste lands. Areas covered by efflorescence and poor soils lie at such low levels as to be difficult of proper drainage. Every excess of water used for irrigating the higher lands beyond that actually required for the growth of the crops injuriously effects the lower lands. No doubt that the introduction of perennial irrigation in the XIXth century without corresponding drainage has greatly helped the accumulation of salts and the development of salted areas. Moreover the construction of high-level canals has led to similar mischief, since the seepage water from these canals, after washing the very salty limestones and clays through which the canals are cut, drains on to the lower levels and there gives rise to an accumulation of harmful material or waterlogs the soil. The efflorescence is usually resultant upon the rise and subsequent evaporation of the seepage water from these canals.

Salts are not all equally injurious. Sodium carbonate is the most harmful to vegetation and has a corrosive action upon the plant tissues. The rate of plant indurance for various harmful salts depends on many factors as, the kind of salt, the type of plant and its age, the nature of the soil, and extent of other salts present. The following table gives limits of endurance for ordinary crops [1].

Sodium carbonate : 0.05 % minimum danger line
—— : 0.10 % maximum limit for growth.
Sodium sulphate and sodium chloride :
0. to 0.25 % not harmful.
0.25 to 0.50 % harmful but not sufficient to prevent growth.
0.50 % maximum limit for growth.

Main remedies are : *a*) effective drainage and prevention of leakage from canals if possible, *b*) economy in the use of water. Scattered patches, bordering the southern shore of Lake Qarûn, and at both sides of Danial drain of eastern Gharaq Basin, have been recently reclaimed. They have been washed several times and then treated by amelioration crops as samar, dineba and rice. Where sodium carbonate is known to occur in excess, supplementary aids to the restoration of the waste land to a satisfactory condition of fertility are adopted. Such aids are the application of gypsum; the addition and ploughing in of sand, carbonate of lime or lime. These methods make clay of saline soils more friable, more pervious to water, and more easily washed.

[1] LUCAS, *A preliminary investigation of the soil and water of the Fayum Province*, Cairo, 1902, p. 8; *Soil and water of the Wadi Tumilat lands*, p. 15.

B) The sandy soil :

The soil of the Fayum depression is not all black and fertile. Several patches of high lying gravel and sand are spotted here and there amidst the cultivated areas [1]. Such patches specially appear to the south of both Tamiya and Matar Tares, and in the Gharaq basin. They represent high and consolidated portions that were not covered with Nile mud.

From the land use point of view, this sandy soil has not yet been tilled due to its deficiency in salts and minerals essential to plant life, and lack of necessary water. However, such a sandy soil can be ameliorated if it is mixed with clay from neighbouring areas and if water can reach it from near-by canals. The writer hopes that this sandy soil will be well exploited in the near future. Such soil is excellent for the cultivation of fruits with vines and figs as the principal products.

From the land use standpoint, the main questions of the Fayum soils which seem to require study are : (1) the character of the soil; (2) the movement of the subsoil water; (3) the nature and distribution of the salts; (4) perfect methods of reclamation; (5) nature of chemical constituents in which these soils are deficient, and which therefore require to be added in the form of manures [2].

III. WATER SUPPLY

The Fayum depression has a desert climate of a very arid type, mild winters with very little rain and hot rainless summers. The country enjoys all the advantages of a desert climate, great dryness of the air and bright and prolonged sunshine. However, the rainfall is exceedingly small, averaging less than a centimetre a year. The following table

[1] *Map of the Fayum Province,* 1 : 100.000, published by the Survey of Egypt, 1929.

[2] Mosséri (M.), *Le drainage en Egypte, Bull. de l'Union Syndicale des Agric. d'Egypte,* fév. 1910, p. 33; Anderson (L.), *Land reclamation, journ. Khed. Agric. Soc.,* Cairo, t. V, 1903, pp. 249-265; Hume (W.F.), *Geology of Egypt,* volume I, Cairo, 1925, p. 174-188.

gives the average monthly rainfalls in millimetres recorded at the meteorological station of Shakshuk, on the southern shore of lake Qarûn for :

A) the years 1928-1935 inclusive; B) year 1947.

Years [1]	Jan.	Feb.	Mch.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1928-1935..	1.5	2.1	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	2.8	7.9
1947	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	11.0

As far as agriculture is concerned, such a small quantity of rain is of course negligible, and all the rain which falls on the land is at once absorbed or evaporated. Therefore, agriculture of the Fayum depends entirely on the supply of irrigation water from the Nile [2].

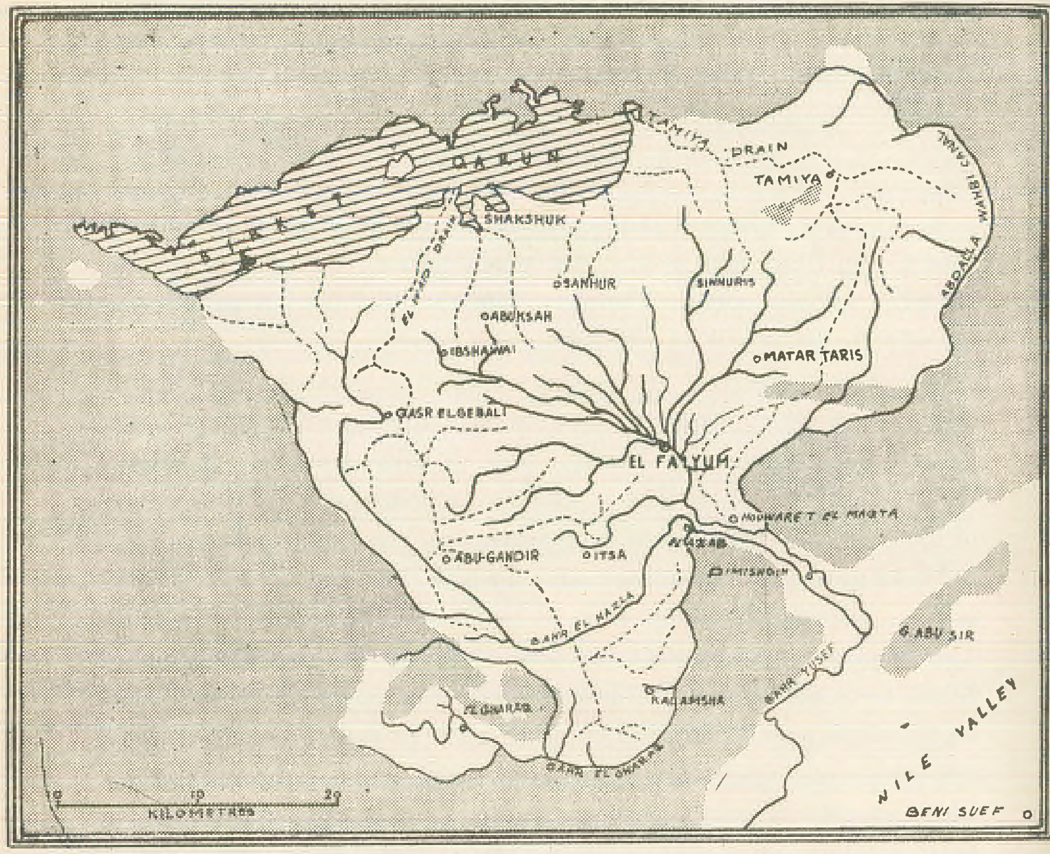
Bahr Yusef represents the main canal which supplies the Fayum with all irrigation water. Until about 1869, that stream used to take its water directly from the river at Dairut. Now, it takes from the Ibrahimia canal, which itself takes off from the Nile at a point immediately upstream of the Asyût Barrage [3]. The canal leaves the Nile Valley at Lahun, and follows a somewhat serpentine course through the desert for bout 5 kilometres, irrigating a narrow strip of land on either side. When Bahr Yusef enters the wide cultivated area of Fayum, it gives off numerous subsidiary canals which traverse the country in many directions, constantly splitting up into smaller branches until the water-supply is divided throughout the whole area. The main canals are Abdalla Wahbi canal which irrigates a good part of the northeastern section, Bahr el Nazla canal which supplies most of the western section with necessary water, and Bahr el Gharaq canal which is the main source of water in the Gharaq basin and which takes off from Bahr Yusef soon after the latter enters the Fayum.

[1] Ball, *op. cit.,* p. 225; *Meteorological Report for the years* 1945-1947, Cairo, 1950, p. 157.

[2] Murray (G. W.), *The Artisian water beneath the Libyan desert* (*Bulletin de la Société de Géographie d'Egypte,* t. XXV, mars 1953, p. 91).

[3] Willcocks (W.) and Craig (J.), *Egyptian Irrigation,* London, 1913, vol. I, p. 444.

The sketch map, given with this paper, shows the manner in which the water that enters the Fayum by Bahr Yusef is distributed over the lands of the province by subsidiary canals. The map shows also that



Irrigation and Drainage systems of the Fayum.
The continuous lines indicate the canals, the dotted lines the drains.

some of the distributary canals are circumferenial, taking off from Bahr Yusef and serving to irrigate the lands nearest to the desert margin. Other canals, which are more numerous, are radial and take off from Bahr Yusef near Madinet el Fayum to irrigate the remaining lands. These distributary canals, after having watered land on either side of them, terminate as a rule in blind ends.

The drainage system of the Fayum is shown by the dotted lines on the

sketch map. Drains generally interdigitate with the canals, and in few cases are siphoned under them. All drainage water is carried into lake Qarûn, where it is disposed of by evaporation. Most of drainage water is passed into the lake by two main channels called respectively the Wadi drain and the Tamiya drain; the first debouches into the lake near the mid-point of its southern shore, and the second drops its water at its eastern end. As can be seen from the accompanying map, there are many smaller drains which reach the lake carrying the remaining water.

The province is naturally drained, except Gharaq basin where three pumping stations help to carry drainage water to Danial drain which reaches the Wadi drain near Abu-Gandir [1].

Resultant upon perennial irrigation, the soil is never allowed to dry for very long at a time, and canals are usually running full of water at a high level. Great efforts have been made to furnish the whole area with a good drainage system. Main drains were widened or realigned, subsidiary drains were constructed, and powerful pumps were installed to lift water into major drains. However, it seems certain that until field drains are widely constructed to give every acre of perennially cultivated land its own direct access to the lake, the problem of drainage cannot be considered as solved.

Another problem should be refered to, namely, the project of Wadi Rayan Reservoir and the possibility of infiltration from the Wadi into the Fayum. The Wadi Rayan depression lies to the west of the Fayum Province. Its maximum depth is about 50 metres below sea-level as compared with the 45 metres of the present lake Qarûn level. A dividing ridge separates the two depressions. Its capacity at various levels is :

below	contour	0	metres	6.1	milliards cubic metres
—	—	10	—	9.6	—
—	—	20	—	14.4	—
—	—	24	—	16.8	—
—	—	30	—	20.8	—

[1] Ibrahim Rakshy, *Irrigation and drainage of Fayum Province,* pp. 62-64. (*The Engineers' Magazine,* july-august, 1947) [in arabic]; Labib Gohar, *Drainage Project of Gharaq basin,* Fayum Province, p. 65-76. (*The Engineers' Magazine,* july-august, 1947) [in arabic].

The expense and the possibility of infiltration from the Wadi to the Fayum are the main objections against the project. According to Hurst and Simaika [1], it seems very likely that if there are no definite large and continuous cracks connecting the Wadi and the Fayum depression, the silty water of the flood would in a very short time make the rock impermiable. If there are definite cracks, these would show themselves when the Wadi is filled and could easily be dealt with, since it is not to be expected that large volume would infiltrate.

Apart from the reservoir project, the Wadi is a promising site for land reclamation by means of a small canal from Bahr Yusef to lead in the water. Silty water would enrich the soil and make the present desert fertile. The area of the Wadi at contour 27 is about 160.000 feddans. The higher land would be put under cultivation and the bottom of the Wadi would receive the drainage.

(1) HURST, SIMAIKA, *The Nile Basin,* volume VII, Cairo 1946, pp. 49-50.

REMARKS ON THE GEOLOGICAL STRUCTURE OF EGYPT

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PART I

THE CRETACEOUS-EOCENE RELATIONS

I. INTRODUCTION.

This note is the first of two papers dealing with some aspects of the geological structure of Egypt. It synthesizes our knowledge of the Cretaceous-Eocene contact in Egypt and is an attempt to give an interpretation of the rather complex relations of the two systems. In preparing this paper the author did not depend on his experience alone, but has drawn freely on the wealth of information disseminated in the voluminous literature on the subject, and on the data, both geological and geophysical, conveyed to him by the geologists of Oil Companies in Egypt.

The problem of the Cretaceous-Eocene contact in Egypt is a controversial problem which remains still vague and unsolved as shown by the following review of the literature.

Zittel (1883, p. 90) was one of the earliest writers to discuss this problem and to advocate continuous sedimentation between the Cretaceous and Eocene. Basing his conclusions on his observations in the Libyan Desert, he noticed that « there is no sharp demarcation between the two systems, no disturbance in the succession and there are no intercalated fresh water deposits at any part of the section and there is not a

trace of a hiatus between the two systems». The Libyan Desert, in his opinion, offers one of the rare complete records in the world of marine sedimentation during the Upper Cretaceous and Lower Eocene where no volcanic activity occurred during the transition and where even lithological change between the two systems is not sharply marked. He considered this discovery as one of the greatest achievements of the Rholf's Expedition which he accompanied.

Zittel's conclusions seem to have left a marked impression on the thoughts of many later geologists. Beadnell (1905) emphatically pointed out from examples in widely separated areas in southern Egypt, particulary in the Nile Valley, of the perfectly conformable relations of the Cretaceous and Eocene systems. In a later work Beadnell (1927, p. 26) extended his conclusions to Sinai Peninsula, pointing out the complete absence of any unconformity between the two systems and stating that continuous sedimentation is everywhere evident and that wherever a conglomerate is present it is to be a crush conglomerate along a nearly horizontal thrust-plane as in Gebel Abiad. His arguments were in answer to Barron's conclusions (1907 *a*) asserting the presence of a break in sedimentation between the Cretaceous and Eocene in Western Sinai. It is indeed remarkable to find such broad generalizations put forward by the first author who describes accurately and in detail the famous Cretaceous-Eocene unconformity in Abu Roash (1902) and the classic unconformity between the two systems in Bahariya Oasis (1903).

Picard (1943) is of the opinion that continuous sedimentation occurred during the transitional Cretaceous-Eocene time, although he admits the presence of discordance at several localities in Egypt. He explained these latter occasional relations as due to epeirogenic movements that brought N.-S. swells in the country along which unconformities were present. If Picard's interpretations were carried to the field, an unconformity should be present all along his N.-S. swells, which is not true.

Tromp (1942) made the emphatic statement that an erosional hiatus at the top of the Cretaceous does not exist. He later (1949) asserted his views of continuous sedimentation between the two systems, although he recognized an important regional hiatus at the base of the Middle Eocene causing overlap relations which may have been the cause of the erroneous interpretation of the relations of the rocks of the Cretaceous and Eocene.

Faris (1947) discussing the Cretaceous-Eocene contact in the Tramsa-Tukh (Quena area) came to the conclusion that the entire southern part of Egypt was covered during the Paleocene thus supporting Zittel's earlier contention of continuous sedimentation between the two systems. The same author (1948, p. 237) attributed the occasional unconformities between the Cretaceous and Eocene in Abu Roash and Shabrawet to folding which affected local rises due to lateral contractions of the crust, while on the following page (1948, p. 238) he agreed with Picard (1943) in ascribing these unconformities to epeirogenic movements.

Several authors, on the other hand, believed in the presence of a marked unconformity between the Cretaceous and Eocene. Boussac (1913) basing his opinion on paleontological grounds, believed that no Lower Eocene exists in Egypt, a great transgression occurred during the Middle Eocene time with the result of a tremendous unconformity between the Cretaceous and Eocene systems. Cuvillier (1930) was inclined to believe that an unconformity existed between the Cretaceous and Eocene except at a few localities (Farafra and Askar el-Bahariya at the extreme north of el-Galala el-Quiblia). He interpreted the conformable relations as due to gulfs that extended over these areas during the Lower Eocene regression. According to this author (1930, p. 65 and palaeogeographic map) no authentic Lower Eocene exists in Sinai except near Lake Timsah (Ismailia), a statement which later field work proved untrue. In a later work, Cuvillier (1949) seems to have abandoned his previous ideas and to have accepted the idea of continuous sedimentation between the Cretaceous and Eocene in Upper Egypt.

Ball (1939, p. 22) maintains also the opinion of the presence of a great unconformity between the Cretaceous and Eocene. He believed that at the close of the Cretaceous Period, the sea retreated at least as far northward as the latitude of Cairo as shown by « the decided unconformity which exists between the Cretaceous strata and the overlying Eocene deposits at Abu Roash, near the Pyramids of Guiza».

Blanckenhorn (1921, p. 74) appears to be of the opinion that a break in sedimentation exists between the Cretaceous and Eocene strata causing

the absence of the Lower Eocene beds in Sinai and Northern Galala and most of the Lower Eocene in Abu Roash and Bahariya Oasis. He was, however, one of the earliest authors to recognize the longitudinal N.E.-S.W. folded anticlinal chain of mountains that rose from the bottom of the Cretaceous sea at its close and which accounted for the changing bio-and lithofacies of the Lower Eocene and the discordant relations of the Eocene over the Cretaceous deposits.

It is obvious from the above discussion that the problem of the Cretaceous-Eocene contact in Egypt is far from being solved. In the following lines a new approach to the subject is suggested whereby the author believes that both conformable and unconformable relations do exist in Egypt and gives an explanation of these relations.

II. Field Relations.

A list of localities where an unconformity between the two systems is known, is recorded in the following lines (all the sections in Sinai were measured by the geologists of the Standard Oil Co. of N.J., except when stated otherwise) :

1. *Mersa Matruh, Western Desert, Mediterranean Coast :* A boring at this locality gave the following section :

Pliocene	102 m.
Miocene..........................	228 m.
Eocene	263 m.
Cretaceous?	190 m.

The thickness, dips, position and high gravity anomalies suggest a break between? Cretaceous and Eocene.

2. *Ras el Dabaa, Western Desert, Mediterranean Coast :* A boring in this locality executed by the Anglo-Egyptian Oilfields Ltd. gave the following section :

Pliocene	125 m.
Miocene..........................	460 m.
Oligocene	300 m.
Eocene	278 m.
................unconformity	
Upper Cretaceous	330 m.
Cenomanian.......................	590 m.

The dips and the thickness of the Eocene in the section suggest an unconformity between the Upper Cretaceous and Middle Eocene. Gravity measurements also point in the same direction.

3. *Qaret-Agnes, Western Desert :* Gravity measurements at Qaret-Agnes and Moghra Oasis indicated a high gravity anomaly which might indicate a domal structure underneath.

4. *Khatatba, Western Desert :* A wild-cat, well (No. 1), drilled by the South Mediterranean Oil Co. gave the following section :

Raml Formation (Oligocene)	110 m.
Haddadin Basalt (Oligocene)	29 m.
Upper Eocene......................	130 m.
...................unconformity	
Middle Cretaceous.................	138 m.
...................unconformity	
Basement.........................	24 m.

A clear-cut unconformity between the Middle Cretaceous and Upper Eocene is recorded in this well.

5. *Abu Roash, near Cairo :* The classic Cretaceous-Eocene unconformity has been first recognized by Beadnell (1902) and by numerous authors, the most recent of them is Faris (1948). Work of Oil Companies in the area has proved that the age of the unconformably overlying Eocene rocks varies in the different structures. In the north (Abu Roash anticline), Upper Eocene beds directly overlie the Upper Senonian; in the SW of Sudr el-Khamis (syncline between el-Ghigiga and Hiqaf anticlines) Lower Middle Eocene is recorded on top of the Upper Senonian, while in the south (Giran el Ful) Middle Eocene overlies the Upper Senonian Chalk. The oldest core recorded is Cenomanian.

6. *Shabrawet, near Ismailia :* This excellent domal structure with a clearly defined unconformity between the Cretaceous and Eocene strata has been described by Barron (1907), Barthoux (1922) and Krenkal,

after Blanckenhorn (1925, fig. 31, p. 139) and others. The following section was measured at this locality :

Middle Eocene	
....................unconformity	
Turonian..........................	150 m.
Cenomanian........................	300 m.
Nubian S. S.	400 m.
(core of nearly overfolded strata)....	

7. *Gebel Moghara, N. Sinai :* Geologists of the Strandard Oil Co. described a section at Wadi el Mushabbi (Gebel Moghara) in which Middle Eocene lies unconformably on Upper Senonian. Again an unconformity between the Cretaceous and Eocene is marked by a conglomerate (Farag, 1941, p. 285) and the Eocene and Upper Cretaceous strata are more gently dipping than the underlying highly tilted Lower Cretaceous, a fact which may indicate another unconformity between the Lower and Upper Cretaceous (Moon and Sadek, 1921). Core of structure is Jurassic. Similar structures are known in Risan Eneiza and Gebel el-Mistan to the NE of the Moghara dome.

8. *Bahariya Oasis, Western Desert :* Ball and Beadnell (1903) and Blanckenhorn (1921, fig. 4, p. 18) described in detail the sedimentary succession in the area and showed a Middle Eocene-Upper Senonian (Campanian) unconformity. The core of the structure is Cenomanian.

9. *Wadi el-Rayan, south-west Fayum, Western Desert :* Only Middle Eocene rocks are found exposed everywhere, but geophysical work carried out in the area by Standard Oil Co. geologists points to a large gravity and magnetic maxima which cannot be explained by the low relief surface uplift of the Wadi. « It is almost certain that this structure was already well developed in Cretaceous and older rocks before deposition of the Eocene rocks which now blanket the area. There is little doubt about this point. The gravity crest coincides with the structural crest in the Eocene but the gravity amplitude demands three or four times the structural relief that is shown on the structure contour map. Also the west end of the gravity anomaly does not coincide with Eocene structure, which again indicates structure below the Eocene and an unconformity».

10. *Gebel Ataqa, south of Suez :* Barron (1907, p. 101) described the succession in Gebel Ataqa and noticed a gypseous bed 25-30 m. thick which he regarded as the top of the Cretaceous as casts of *Nummulites gizehensis* occur above it. In spite of the fact that this author did not specifically record an unconformity, it is implicit from his description, as *N. gizehensis* beds (Lutetian) overlie immediately the top Cretaceous gypseous bed.

Sadek (1926, pp. 37-39), describing the geology of Gebel Ataqa marked, in the legend of figure 6, the Middle Eocene as overlying directly the Cretaceous. In his description he noted that the top Cretaceous sandy marls which he regarded as Senonian « may therefore represent a local emergence sometime between Cretaceous and Middle Eocene». He further noted (*op. cit.*, p. 45) that in the Ataqa scarp « no Lower Eocene beds were noted above the Cretaceous», the limestones following the Cretaceous being rich in *Nummulites gizehensis* and are therefore of Middle Eocene age. He concludes by saying : « It seems that here an emergence possibly of local importance, has preceded the Middle Eocene in this part of the district; though on this question more evidence is still needed».

The following is the result of a measured section at Ataqa :

Middle Eocene.....................	200 m.
....................unconformity	
? Lower Senonian and Turonian......	360 m.
Cenomanian.......................	120 m.

There is a marked unconformity between the Cretaceous and Eocene. The contact between the Cenomanian and Turonian is not well defined and all the shales are considered as Cenomanian.

The gypsum described by Barron is considered to be at the base of the Lutetian, while all the dolomitic limestones are regarded as Turonian. Whether Lower Senonian (Santonian) or Upper Senonian (Campanian) is present or not is not quite clear, but the Paleocene and Lower Eocene are certainly missing.

11. *Gebel Yelleg, N. Sinai :* In this asymetrical anticline, a Campanian (Upper Senonian)—Santonian (Lower Senonian) unconformity is noticed

by Moon and Sadek (1921, p. 100) where changing dips and a conglomerate (in Wadi Um Mitla) are recorded. The core of the structure is pre-Cenomanian Nubian Sandstone.

12. *Gebel Giddi, N. Sinai :* The domal structure of Gebel Giddi shows several unconformities between the Upper Cretaceous and Paleocene and between the latter and the Middle Eocene as shown by the following section measured at Gebel Ugret el Aiyada (Lat. 30° 11′ N; Long. 33° 13′ E) :

Middle Eocene	10 m.
...unconformity	
Paleocene	39 m.
...unconformity	
Upper Senonian	5 m.

13. *Maqfi Section :* 69 kms. N 65° 00′ E of the village of Qasr Farafra, Farafra Oasis, Western Desert : In his recent paper on the area, Le Roy (1953) measured the following section :

Lower Eocene (Esna Shale included as unit II)	25 m.
...unconformity	
Basal Eocene (Paleocene?)	25 m.
...disconformity	
Maestrichtian	50 m.

Le Roy considers the Esna shales as Lower Eocene. In the previous sections the Esna shales are included in the Paleocene. Le Roy's Maestrichtian is part of the Upper Senonian of the sections. The unconformities mentioned by Le Roy are of minor magnitudes and cover short lapses of time.

14. *Wadi Araba :* The classic anticline of Wadi Araba shows unconformity between the gently dipping Eocene strata and the more steeply dipping Upper Cretaceous rocks (Blanckenhorn, 1921, fig. 14, p. 41).

15. *Gebel Raha, Gebel Sudr, Sinai :* An unconformity between the Upper Senonian and the Lower Middle Eocene marked by a conglomerate (Cuvillier, 1930, p. 40 and p. 129) is known to exist. The unconformity is even more marked in the Gebel Somar anticline a few kilometres to the south of Gebel Raha where the core of the structure is

Cenomanian (See also Barthoux, 1924, pp. 577-578). An unconformity is also known between the Cretaceous and Eocene of the Hamra Dome.

16. *Gebel Kherim, Sinai :* The following section measured at Lat. 30° 17′ N., Long. 34° E. shows a Lower Senonian (Santonian)-Paleocene unconformity :

Paleocene	3 m.
...unconformity	
Lower Senonian (Santonian)	78 m.

17. *Gebel Ureif el-Naga, Sinai :* The following section measured at Lat. 30° 21′ 30″ N.; Long. 34° 28′ E. shows two unconformities in the succession :

Middle Eocene (undifferentiated)	97 m.
...unconformity	
Paleocene (Esna shales)	13 m.
...unconformity	
Upper Senonian	21 m.
Lower Senonian	100 m.
Turonian	156 m.
Cenomanian	350 m.
Lower Cretaceous & Jurassic Nubian Sandstone	295 m.
Triassic	158 m.
Pre-Triassic Nubian Sandstone	79 m.

18. *Wadi Rumman, Palestine :* The following section measured at Lat. 30° 35′ N.; Long. 34° 52′ E. shows a marked unconformity between the Upper Senonian (Campanian) and the Middle Eocene :

Middle Eocene	20 m.
...unconformity	
Upper Senonian (Campanian)	2 m.
Lower Senonian (Santonian)	43 m.
Turonian	42 m.
Cenomanian	620 m.
Nubian Sandstone	600 m.
Jurassic	97.5 m.
Triassic	436.5 m.

19. *Kharga Oasis :* Ball (1900) recorded an unconformity between the Cretaceous and Eocene strata.

20. *Gebel Abiad, West-Central Sinai* : Barron (1907) found nummulitic and *Operculina* limestones to which he assigns an Upper Eocene age unconformably overlying Upper Senonian (Campanian) limestones with a dip of about 5° to the south-west.

A list of some localities where continuous sedimentation between the Cretaceous and Eocene is recorded is given hereunder :

1. *Bir el-Hassana, Sinai* : At Lat. 30° 26′ N.; Long. 33° 47′ E., the section is as follows :

Lower Eocene (Safra Beds)	20 m.
Paleocene	75 m.
Upper Senonian (Danian)	2 m.

2. *South of Gebel Yelleg, Sinai* : The following is the result of a measured section at Lat. 30° 13′ N.; Long. 33° 35′ E. :

Lower Eocene	10 m.
Paleocene	50 m.
Upper Senonian :	
(Maestrichtian)	73 m.
(Campanian)	6 m.
Lower Senonian (Santonian)	35 m.

3. *Gebel el-Bruk, Sinai* : At Lat. 30° 11′ N.; Long. 33° 42′ E., a section was measured as follows :

Lower Eocene (Egma Limestone)	64 m.
Lower Eocene (Safra Beds)	15 m.
Paleocene	56 m.
Upper Senonian	130 m.
Lower Senonian	125 m.

4. *Gebel el-Mattalla, Sinai* : The following is the result of a measured section at Lat. 30° 10′ N.; Long. 33° 58′ E. :

Lower Eocene (Safra Beds)	21.2 m.
Paleocene	72 m.
Upper Senonian (Danian)	2 (Base unexposed)

5. *Gebel Shaira, Sinai* : (Lat. 30° 6′ 48″ N.; Long. 34° 16′ 40″ E.) the section ran as follows :

Lower Eocene (Egma Limestone)	80 m.
Lower Eocene (Safra Beds)	20 m.
Paleocene	76 m.
Upper Senonian (Danian)	(Base unexposed)

6. *Hamth and Nekhl, Sinai* : Gravity measurements conform with the surface structure indicating that the Upper Senonian do not show different dips or an unconformity with the exposed Eocene. At Ras Abu Gidil, Lat. 29° 50′ N.; Long. 33° 34′ E., the section runs as follows :

Lower Eocene (Egma Limestone)	85 m.
Lower Eocene (Safra Beds)	20 m.
Paleocene	55 m.
Upper Senonian (Danian)	141 m.
unconformity	
Lower Senonian	50 m.

7. *Gebel Nezzazet, Sinai* : The following is the result of a measured section at Lat. 28° 45′ N.; Long. 33° 16′ E. :

Lower Eocene	115 m.
Paleocene	50 m.
Upper Senonian	170 m.
Lower Senonian	104 m.
Turonian	80 m.
Cenomanian	198 m.
Nubian Sandstone	880 m.

8. *Wadi Danili, Sinai* : See Nakkady (1950).

9. *Wadi Abu Durba, Sinai* : See Nakkady (1950).

10. *Wadi Mellaha, Eastern Desert* : See Nakkady (1950).

11. *Gebel Duwi, Eastern Desert* : See section given by Nakkady (1950).

12. *Tramsa-Tukh, Qena Area Nile Valley* : See section given by Faris (1947).

13. *El-Gus Abu Said, Farafra Oasis, Western Desert* : This is a classic locality showing continuous sedimentation between the Cretaceous and Eocene. Zittel (1883) and Cuvillier (1930) recorded measured sections in the area.

Many other localities could be cited, specially in Sinai and the Nile Valley in Upper Egypt where the writer confirms the presence of continuous sedimentation between the two systems. It is to be noticed that at one and the same area (*e. g.* Gebel Moghara, Yelleg, Falig, etc.) both complete and incomplete sections (showing both continuity and discontinuity in sedimentation) are recorded.

III. Discussion.

As can be seen from the above sections, both conformable and unconformable conditions exist between the Cretaceous and Eocene strata. Unconformities between the two systems show different breaks as could be seen from the following :

Upper Senonian (Campanian)-Upper Eocene as in the northern flank of the Abu Roash structure, or between Upper Senonian (Campanian) and Middle Eocene as in Bahariya Oasis or SE of Sudr el-Khamis in Abu Roash area or in Gebel Raha ; or between Upper Senonian (Danian) and Lower Eocene as in Kharga Oasis or Dakhla Oasis (Cuvillier, 1930) or between Middle Cretaceous and Upper Eocene as in Khatatba ; or between Lower Senonian (Santonian) and Paleocene as in Gebel Kherim ; or between Upper Senonian (Maestrichtian) and Paleocene as in Gebel Giddi ; or between Turonian and Middle Eocene as in Shabrawet.

Furthermore unconformities have been recorded within the Cretaceous system. A Lower Senonian (Santonian)-Upper Senonian (Campanian) unconformity is recorded in Gebel Yelleg (Moon and Sadek, 1921, p. 100) and by Tromp (1950). A Lower Senonian (Santonian)-Upper Senonian (Danian) unconformity is seen at Ras Abu Gidil and a Turonian-Senonian unconformity is observed at Moghara.

Unconformities are also recorded within the «Eocene» itself ; between the Paleocene and Middle Eocene as in Gebel Giddi, and Ureif el-Naga ; and in the Middle Eocene itself as in Gebel Mokattam (Cuvillier, 1927).

Cuvillier attempted to explain these varied unconformities together with the perfect concordances known at many localities by assuming the presence of N.-S. gulfs which covered areas with continuous sedimentation. Cuvillier's idea could be visualized as a possibility at the time of the publication of his important thesis (1930) as only two localities were then known to have continuous sedimentation. With our present knowledge of the presence of continuous sedimentation at many localities and of the presence of varied relations within small distances, it is impossible to explain such a complex and puzzling picture only by annexing gulfs to ancient seas.

This problem drew also the attention of Picard (1943) who assumed that «the Libyan-Egyptian gulfs of the Paleocene, had a rich configuration of the coast line, divided up into many peninsulas, islands and partial bays». He also believed that «this island-penninsula world» must have been produced by epeirogenic movements. According to his map (*op. cit.*, p. 38) there are north-south swells. Facts at hand prove, however, that discordances between the Cretaceous and Eocene do not follow this direction ; on the contrary, perfect unconformity is recorded in more than one locality just south of perfectly concordant strata (for example unconformity at Gebel Ataqa is followed southward by conformable relations at El-Galala-el-Bahariya followed by an unconformity at Wadi Araba and then by a conformable sequence at El-Galala el-Qibliya).

It is the opinion of the writer that the discontinuity of sedimentation was controlled by the structural highs that belong to the so-called Syrian «arcs». These structural highs have a N.E.-S.W. direction and are important features in the structure of Egypt and the Levantines (Krenkel, 1925, fig. 101, p. 104 and 136 ; Sadek, 1928 ; Picard, 1943, fig. 1, p. 6). Chart I shows the main highs based on the available data. It is to be noted that the number of highs shown on the chart is greater than those given by earlier workers and are different in their trends. Krenkel (1925), for instance, puts Abu Roash, Baharia and Farafra structures on one line. In this work they are considered as lying on three separate independent trends. It seems that Krenkel put these three localities on one line following the trend of the lines in Syria and Palestine. However, the lines are now known to change their trend from N.N.E-S.S.W. in the north to a more or less E.N.E.-W.S.W. direction in Egypt. The main lines are :

1. *Matruh line.*

2. *Dabaa line.*

3. *Qattara line.*

4. *Maghra-Garet Agnes* (Gravity highs).

5. *Khatatba line :* passing through Gebel Agila, Gebel Gedaa, Gebel Ruzza and Khatatba (Gravity high).

6. *Abu Roash line :* passing through Abu Roash, Shabrawet, Moghara, el-Mistan and Gebel Gehan with a separate "arc" of Hamayir—Mafruth—Risan Eneiza (Moon & Sadek, 1921, Plate III) farther north.

7. *Halal line :* passing through Bahariya Oasis, Wadi el-Rayan, Ataqa, Halal, Yelleg, Giddi and Nahlin (Palestine).

8. *Wadi Araba line :* passing through Farafra Oasis, Wadi Araba, Somar, el-Bruk, Kherim, el-Meneidra, Ureif el-Naga and Gebel Rumman (Palestine).

These are general lines and should be considered only as tentative and subject to modification when more data become available. Less conspicuous lines do exist as in Gebel Hamth, Abu Sultan (gravity high), Gebel Abiad, Anqabia and Nasuri and Gebel Iweibed etc. The presence of an inlier of Pre-Cambrian basement complex N.E. of Bir Terfawi and of Gebel Owenat (S.W. extremity of Egypt) may suggest the possible presence of an "arc" that may extend along these two localities assuming that no faulting exists. These inliers cannot be attributed to deposition on an irregular surface as a pre-Nubian peneplain is known to exist. This line may be in continuity with the anticline mentioned by Hume (1912, p. 7) to exist to the south of Wadi Qena.

The highs have been affected by younger faulting (of clysmic and Mediterranean directions) changing their positions as could be asserted by the pitching of Wadi Araba westward and the change of direction of many of the folds in the Cairo-Suez area (*e.g.* at Gebel Nasuri and Anqabia).

The highs are more pronounced and crowded in the north towards the Tethys geosyncline than in the south towards the foreland. In Sinai for example, the «arcs» die southward. The well-developed Moghara and Halal highs of the north become represented by relatively minor structures in central Sinai as in Hamth and die farther south in the Egma Plateau.

Between the «arcs» there lie basins : for example, the Hassana and Falig synclines (Between Abu Roash and Halal lines) ; the Gus Abu Said and North of Minshereh basins (between Halal and Wadi Araba lines).

IV. Effect of the highs on the succession of starta in the Cretaceous and Eocene.

The previous survey of the Cretaceous-Eocene contact in Egypt showed a wide range in the length of hiatus represented in the unconformities recorded. It is believed that this depends on the magnitude of the movement affecting each locality. Localities that represented big structural highs showed the most marked unconformities (*e. g.* Moghara and Shabrawet). Again different parts of the same structure showed different unconformable relations of the strata. This is beautifully shown in the Abu Roash area where Upper Eocene directly overlies Upper Senonian in the conspicuous Abu Roash anticline ; Upper Middle Eocene overlies the Upper Senonian in the less pronounced Giran el-Ful anticline ; and Lower Middle Eocene overlies the Upper Senonian in the intervening syncline south of Sudr el-Khamis. Areas which, on the other hand, represented structural lows showed continuous sedimentation (*e. g.* Hassana syncline and the unaffected Egma Plateau [Beadnell, 1927]). At Galala continuous sedimentation is evident, whereas at the crest of the anticline in Wadi Araba an unconformity is known to exist. A less marked unconformity is present along the flank between the synclines and anticlines. This explains the recording of unconformities near complete sections and varied relations at different points in one structure.

As recorded above, it is seen that the stratigraphic position of the unconformities is different. This is explained by the fact that the orogenic movement of the Syrian «arcs» was intermittent from its start at least as early as pre-Upper Cretaceous (notice Moon and Sadek's, 1921

and Tromp's, 1950 unconformity between Turonian and Upper Cretaceous) to its end in late Oligocene time (SHUKRI and AKMAL, 1953). The time of these pulses is different in the different localities, hence the wide variety of unconformable relations to be found on the same line.

V. SUMMARY.

To sum up, Egypt must be visualized as an area with elongated ridges rising from the bottom of the Cretaceous sea, that were intermittently submerged and emerged in later time due to pulsing lateral contractions that were in force up to late Oligocene times. These ridges ran mainly in a N.E.-S.W. direction extending across Egypt and are a continuation of the well-known Syrian « arcs ».

Along these ridges unconformities (within the Cretaceous and Eocene) are recorded. The basins separating these ridges were the sites of continuous sedimentation. The degree to unconformity is governed by the position of the locality relative to the highs (crest and flank) and the amount of arching. The time of the pulses of orogeny is also a governing factor and complicates the picture. Taking into consideration these factors, it is hoped that a better and clearer understanding of the Cretaceous-Eocene contact in Egypt is possible.

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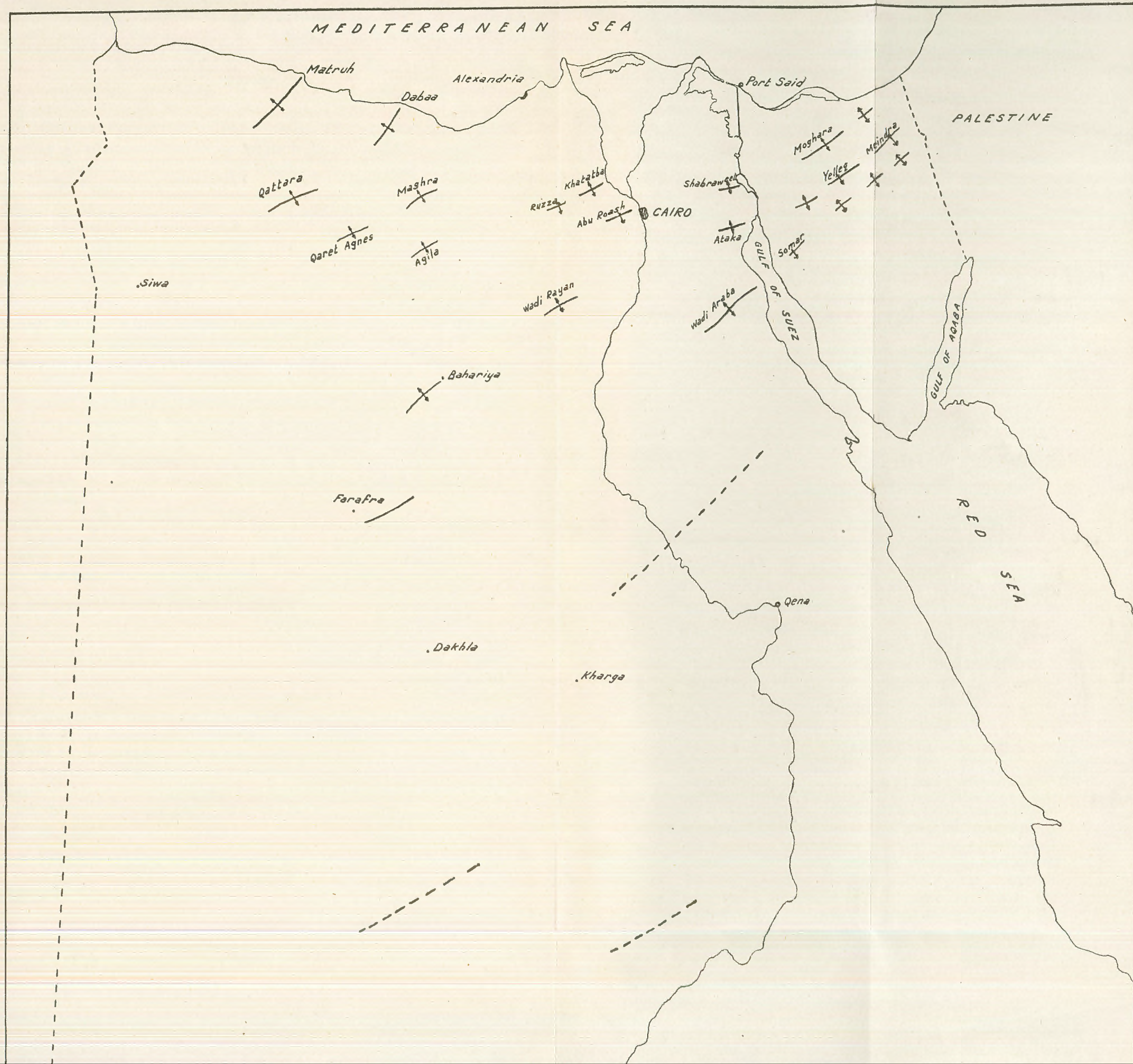

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THE GEOLOGY OF SHADWAN ISLAND

NORTHERN RED SEA

BY

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I. INTRODUCTION.

The writer accompanied the Mabahith Expedition in 1934/1935 (Crossland 1936 and 1939 A and Mohammed 1940) when he examined the different islands situated in the northern part of the Red Sea. A note was published on the geology of the Brothers' Islets (Shukri 1942) and the present work deals with the geology of Shadwan Island situated farther north between Lat. 27° 32′ 6″ N-27° 26′ 36″ N and Long. 33° 53′ 54″ E-34° 2′ 12″ E. It is the largest and highest (about 606 m.) of the group of islands in the strait of Jubal and the only one in which the basement rocks are exposed. Its topography is shown on the Admirality Chart of the Red Sea (Sheet 1 also Admirality Chart of strait of Jubal and map in Pola Expedition Report). Mitchell seems to be the first to examine in any detail the geology of the Island (1887). Later, Hume (1916) gave a vertical section across the Island and Blanckenhorn (1921, p. 124) mentioned the occurrence of Middle and Upper Miocene on it. The pre-Cambrian rocks were described by Mrazec & Rotman (1916 and in Hume 1935, p. 399) who attributed the rocks present (quartz diorites, tonalites and granites) to crystallization differentiation. The basement rocks are formed of older autochtonous granites

formed by the granitization of the country rocks and containing much relics of them (pelitic and hornblendic rocks including andesites) and a newer intrusive granite, showing graphic structure, that is very similar to that of Gebel Zeit and other newer granites present in the northern Eastern Desert.

The basement rocks (pre-Nubian Sandstone) are cut by different dykes including spessartites, bostonites, aplites and basalts. They form the central and south-western parts of the Island and are covered by sediments ranging from Lower Eocene to Recent. The author was the first to note outcrops of Eocene age on Shadwan. The Miocene is represented by a Lower Series formed of basal conglomerates and coral dolomitic limestones and an Upper Series formed of evaporites. Younger sediments of Plio-Pleistocene, Pleistocene and Recent ages are present. The Island has a north west-south east trend and its alignment is determined by the N.W.-S.E. clysmic trend of faults which are of Oligocene or earlier age. Post Miocene movements are known to have continued on the old lines of fractures. These clysmic faults are younger than the Syrian «arcs» as they cut the Wadi Araba anticline and the «grain» of the mainlands (Tromp 1950 and Arkell 1951). A fault between the northern contact of the basement complex and the sedimentary formations is probably related to the Gulf of Aqaba graben and seems to be of a more recent age. The structure of the Gulf of Suez district as a whole is briefly discussed specially the N.W.-S.E. «anticlinal» and «synclinal» areas on both sides of it. The writer wishes to express his admiration of the magnificent pioneer work of the previous workers specially of the Officers of the Geological Survey of Egypt for elucidating the principal geological structure of that part of the country.

II. STRATIGRAPHY.

1. Pre-Nubian Crystalline Basement.

The oldest formations are different country rocks now occurring as relics in the old autochtonous granite. They are represented by pelitic and hornblendic hornfelses. The latter partly consist of hornfelsed andesites. The country rocks are seen in different degrees of alteration

into quasi-igneous rocks of dioritic and granodioritic composition. Later, an intrusive granite showing graphic structure and similar to that at Gebel Zeit seems to be intruded on a small scale into the older granites. The granitic rocks were later intruded by dykes of different composition. The detailed study of the basement rocks of the Island will form the subject matter of a future work.

2. Lower Eocene.

Sediments of this age were discovered in a small outcrop in the S.E. part of the Island. The formation is about 25 metres thick formed of richly fossiliferous hard limestone. Cuvillier (1937) identified *Operculina canalifera* d'Arch, and assigned a lower Lutetian age to the deposit. Said reported upon three thin sections as follows : «There are at least as many as ten species of Foraminifera, Radiolaria and diatoms in the section. Most of them are new and have never been noticed before probably because little work has been done on small larger-Foraminifera. The slides have the following genera : *Assilina, Bigenerina, Textularia, ?Reophax, ?Alveolina*. The only species which could be compared is *Assilina* cf. *nili* de la Harpe. The fauna present strongly suggest a Lower Eocene age». The Geological Dept. of the Anglo-Egyptian Oilfields Ltd. reported as follows : «In examining a portion of the original sample we found *Operculina libyca, Nummulites solitarius* (smaller than usual), *Nummulites Sp.* indeterminable, *Alveolina* cf. *sub-pyrenaica, Alveolina lepidula?* Miliolides, other small Forams, remains of Molusca, Echinoids and Calcareous Algae. We have no doubt that this assemblage is of Lower most Eocene age». Such an age assignment is in agreement with that given by Said and is different from Cuvillier's determination. The presence of Eocene sediments at Shadwan shows that this part of the Red Sea was submerged by the Ypresian Sea (*cp.* Ball, 1939).

3. Miocene.

The Miocene of the Island is divided into two series :

a) A Lower Series formed of basal conglomerates and coral dolomitic reef limestones.

b) An Upper Series formed of evaporites.

a) Lower Series.

This is probably of Lower or Lower Middle Miocene age and it rests unconformably over both the Eocene and the crystalline rocks. This unconformity and the absence of Oligocene sediments show the presence of topographic highs that were subjected to erosion before the deposition of the Miocene. The basal conglomerates are polymictic and contain different pebbles derived from the basement rocks.

The conglomerate is some 10 m. thick while the reef dolomitic limestone is some 15 m. thick. The thin reef dolomitic limestone and the conglomerates of the Lower Series are shallow water deposits that accumulated on the pre-Miocene highs and they correspond to thicker deposits that had been deposited in the deeper topographic lows. This is very clearly shown on the mainland to the west at the Esh-Mehalla range where the dip of the Miocene is a depositional dip and their overlap on the irregular surface of the basement is clearly shown (Andrew, 1934). There is an indication of a lateral variation of the sediments from the reef limestone on the highs to the deeper Globigerina marl in the basins. It is interesting to note that the dolomitic limestones were observed to fill fissures in the crystalline rocks of the basement.

b) Upper Series.

This is represented by some 150 metres of the evaporite series mainly formed of gypsum or anhydrite. It forms high scarps that are conspicuous from a distance. This is a relatively thin section as compared with the 3080 m. of evaporite in sub-surface reported by the Standard Oil Co. in Tawila No. 2 which must be located on a pre-Miocene low. The evaporites in Shadwan are present in three outcrops located south, west and north of the pre-Cambrian basement. The most western in them is faulted against the granitic terrain. Miocene sediments show in places superfacial anticlines, which are probably due to faulting in depth. Similar structures were observed by the writer on Tiran Island at the entrance of the Gulf of Aqaba, where they are more pronounced.

4. Plio-Pleistocene.

These, unconformably overlie the basement rocks and Miocene sediments and are formed of oolitic limestones, chalks and sandy limestones rich in different casts. They form thick deposits in the north-western part of the Island and not less than 300 metres are estimated to be present.

5. Pleistocene to Recent.

They are formed of coral limestone more than 60 m. thick, that unconformably overlie the Plio-Pleistocene oolitic limestones and the Miocene. They contain large very well preserved corals. They occur as « raised reefs » in a terraced form that are very well shown in the south-eastern part of the Island at the light house, where at least 5 such terraces could be discerned. They also occur as gravelly beach deposits, the pebbles of which are derived from the local rocks. Some of these gravels are consolidated and are cut by the present day waves. It is hoped to correlate in the future the different terraces of the Island with those of the Mediterranean Coast and with the eustatic changes in the sea level.

III. STRUCTURE.

Shadwan Island has a N.W.-S.E. trend and is in alignment with the Gulf of Suez graben and the clysmic rifting. Evidence such as the lateral variation of Miocene sediments both in lithology and in thickness points to a pre-Miocene age of the faulting. In the Cairo-Suez district the clysmic faulting is considered as of late oligocene age (Blanckenhorn 1921, Shukri 1953 and Shukri & Akmal, 1953) and in Shadwan it is at least as old as in the Cairo-Suez district—and probably older as Oligocene sediments are absent in the Island.

Evidence of faulting was observed on the north-eastern side of the Island where a fault escarpment could still be discerned parallel with its side and the Island could be looked upon as a tilted block towards the west (antithetic) and could be compared with the Gebel Zeit and Esh Mallaha highs on the mainland. The sunken blocks were tilted until their isostatic equilibrium was reached (Cloos, 1939). In this

connection it is interesting to note that most of the Islands in the northern Red Sea show steep sides towards the open sea and gentler slopes towards the mainland (Crossland, 1939 B, p. 7). This may be due to structures similar to those described in Shadwan.

Previously Krenkel (1925, pp. 96 & 99) considered the Island as being a horst. The Brothers farther south are the summits of a hill about 1000 metres high (Shukri, 1942) and the bottom topography shows step configuration (Crossland 1939 A & B and Badr & Crossland 1939) and seems to be in harmony with a rift structure. Movement along the old N.W.-S.E. fracture lines in post Miocene times is evident in the Cairo-Suez district (Barron, 1907, Shukri 1953 and Shukri & Akmal 1953) and it appears that similar movements took place along the fault that bounds the N.E. side of the Island.

Another fault crossing the Gulf of Suez direction was observed at the northern contact of the granitic mass. It is post Miocene in age and probably post Pleistocene. This may be considered as related to the movements that were the cause of the formation of the Gulf of Aqaba.

From the writer's experience in the Gulf of Suez district and by comparison of the rift vallies (Gregory 1921, Blanckenhorn 1921, Krenkel 1925, p. 99 and fig. 15, p. 98, Cloos 1939, Busk 1945, Shackleton 1951 and others) he is in agreement with a tensional origin of the Gulf of Suez as all the faults on both sides are normal and dip mainly towards the graben. On the eastern mainland in Sinai, the writer confirms that many of the faults are crescentic (Busk 1929). The alleged thrust plane described by Beadnell at Gebel Abiad (1927, p. 26) and by Bowman at Gharandal (1931, Photo no. 2 and p. 16) in western Sinai represent actual unconformities. The antithesis of a compressional origin of the graben had been recently strengthened by McConnell (1951), while Lees (1952, p. 10) ascribed the graben to both compressional and tensional forces. It is the writer's opinion, however, that tension was the dominant factor. Any sign of compression could be explained by the pinching of the sunken blocks between the upthrown sides. The rifting had caused the formation of the so called «anticlinal» and «synclinal» structures of a clysmic trend that are present on both sides of the Gulf. They are mostly antithetically tilted blocks dipping away from

the graben on both sides. The Esh-Mellaha range, for instance, is bounded by a fault on its eastern side and the block is tilted towards the west forming a corresponding syncline. On the other hand the Abu Durba «anticline» is faulted on its western side and the block is tilted towards the east forming the Qaa syncline.

The following is a list of such structures arranged from east to west (see Moon & Sadek 1921, Plate III and Bowman 1931, Plates 16, 23 and 38 and attached map in the present work):

1 Main Egma Syncline	8 Zeit Bay Syncline
2 Main Sinai Eastern Boundary Fault Ridge	9 Ras Gemsa Anticline
3 Nezzazat Anticline	10 Gemse Bay Syncline
4 Qa'a Syncline	11 Esh-Mellaha Ridge
5 Abu Durba Anticline	12 West Esh-Mellaha Syncline
6 Shadwan Jubal Axis	13 Main Red Sea Hills (western boundary fault)
7 Gebel Zeit Anticline	14 Main Geosyncline

It is interesting to notice that the synclines are topographically marked by bays (*e. g.* Gemsa Bay) and the anticlines by headlands (*e. g.* Ras Zeit).

The negative gravity anomaly in grabens (Bullard 1936 and Holmes 1945) should be explained in some other way than compression so as not to contradict the geological evidence. The erosional origin of the Gulf of Suez advocated by Ball (1911) has only a few adherents.

IV. GEOLOGICAL HISTORY.

Some aspects of the Geological history of the Island has been given by Bowman (1931). The complicated history of the Island in pre-Carboniferous times was followed by a period of peneplanation analogous to that which had affected the whole country both in the Eastern Desert and in Sinai. Probably the Island was then submerged during the Mesozoic and was affected by lateral compression that formed the N.E.-S.W. highs in continuity with the Syrian lines of «arcs».

Subsequently the Lower Eocene Sea covered the Island denoting a wider extension of the Ypresian Sea than hitherto known. In post Lower

Eocene and pre-Miocene times the area was affected by block faulting in a N.W.-S.E. direction giving the Island its trend and forming the Gulf of Suez graben and the high « anticlinal » structures on the bordering lands.

This faulting which continued in Miocene and post-Miocene times caused the emergene of the Island and it was in Miocene times that it was resubmerged and the basal conglomerates and reef dolomitic limestones were deposited. The presence of an evaporite series over the Lower Miocene beds showed that the sea at that time was at least partially closed.

The Miocene sea must have retreated and the emerged land was subsequently submerged during the Plio-Pleistocene as sediments of this latter age rest unconformably over the evaporites.

During Pleistocene and Recent times the relative level of the sea with respect to land changed several times causing the formation of several terraces. This change in sea level is due to movements that probably continue till the present day. Recent faulting that may be related to the formation of the Gulf of Aqaba graben had also taken place.

Acknowledgments

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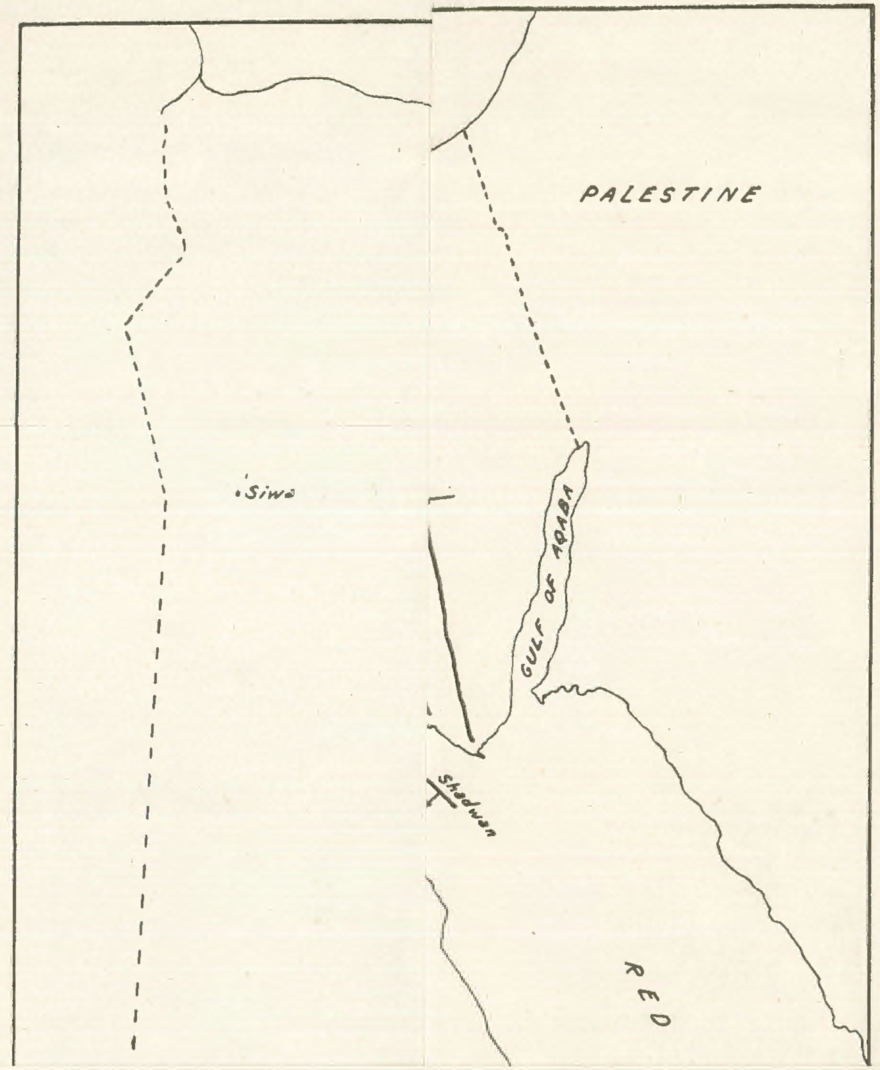

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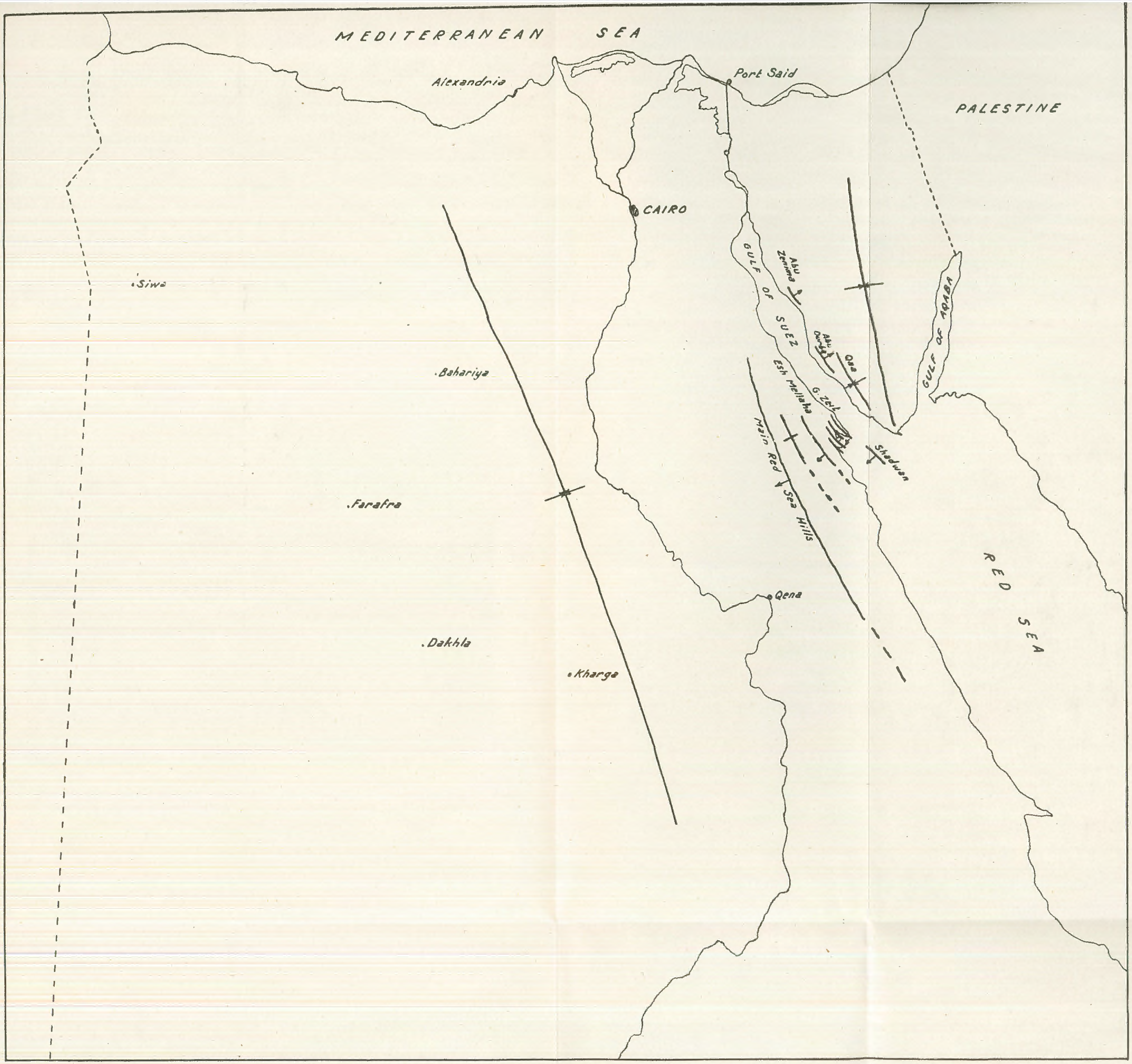

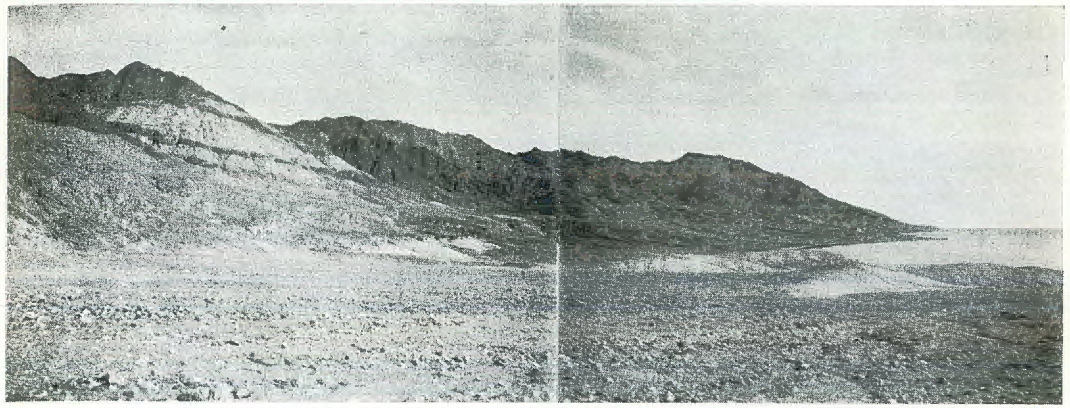

Photo 1 : Basement at S.-W. part of Island showing dark country rocks (« diorites », « tonalites », etc.) and paler granite with xenoliths of the darker rocks.

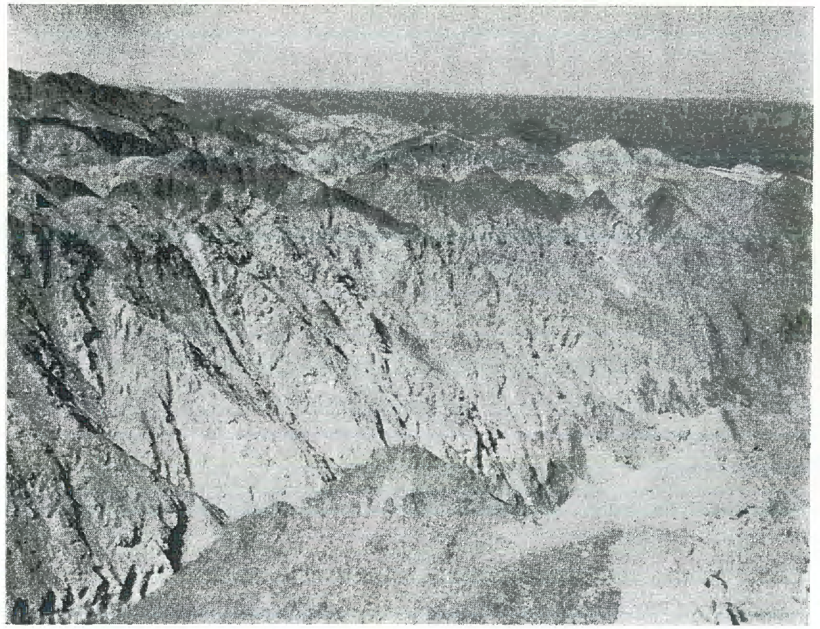

Photo 2 : Basement rocks (granite with xenoliths)—Central part of Island.

Photo 3 : Basaltic dyke in granite.

Photo 4 : Basement rocks (granite with xenoliths) overlain by basal Miocene to the right.

Photo 5 : Showing dolomitic limestone and basal Miocene conglomerates overlying basement rocks.

Photo 6 : Showing « vein » of dolomitic limestone deposited in a fissure in granite.

Photo 7 : Camp at north-western part of Island, showing Plio-Pleistocene oolitic limestones to the right.

Photo 8 : Camp at south-western part of Island, showing recent beach and terraced Pleistocene sediments in background.

REMARKS ON THE GEOMORPHOLOGY OF THE AREA EAST OF HELWAN, EGYPT

BY

RUSHDI SAID

The area east of Helwan, Egypt, offers a remarkable site for a study of landscape development under conditions of arid climate. Being extremely bare due to overgrazing and aridity, this area shows weathering forms and geomorphological features in unexcelled clarity. It is indeed strange that since Walther's work (1900) and Passarge's thesis on the area (1933), not much has been written on this topic. The area under discussion is the strip along the east bank of the River Nile and extends 10 kms east of Helwan into the desert proper, stretching northwards as far as Maadi and southwards some 5 kms south of Helwan. This area is composed mainly of Middle Eocene limestones with patches of downfaulted upper Eocene marly and brownish limestones. The northern boundary of the area is marked by the well-known Maadi fault that separates the Upper Eocene of that village from the southern Middle Eocene rocks. To the west lies the Nile Valley with its Recent alluvium overlapping the cliffs of Helwan. The area is drained by a large number of wadis that flow into the Nile, most important of which are from north to south : Wadi Reshed, Wadi Hof and Wadi Garawi. Endless smaller triburies of these flow in different directions. Because the area does not have an inner drainage, it is not typical as an arid region ; but in regard to all other characteristics it is one of the rare localities where the effect of arid conditions on landscape development can best be studied.

Geomorphological observations in the area support the view, held by the American school, of the minor role that wind plays in the shaping of desert. Having an average rainfall of 1″ a year, this area is considered

as one of the most arid in the world; it represents, nevertheless, geomorphological features and weathering forms that can almost assuredly be ascribed to water action either in the form of running water or penetrating moisture. Most of the Wadis of the area, which doubtlessly were sizable streams in the past, are until now the arteries that collect voluminous quantities of water resulting from the drainage of large areas. In the spring after the rainy season drift wood carried by these channels is seen arranged on the sides of each wadi bed in lines indicating the high water mark. In the spring of 1953, a year of relatively low rainfall, the writer's estimate of the water level in Wadi Hof was 1.20 m. high. Furthermore, along the sides of some wadis, there are some soil formations indicating that the land can store water and render soil. Had it not been for the devastating grazing factors well known in Egyptian deserts, more soil would probably have developed and a vegetative cover would have been formed.

A good portion of the water that does not run into streams soaks and penetrates the rocks underneath. This water together with the moisture of the air is held in the pore spaces of the rock and probably makes the greatest single factor in weathering processes. The relative humidity in the Helwan Desert is by no means low, it averages about 60 in the fall and the winter and is even higher at certain hours of the day. This soaking water when combined with the process of evaporation produces desert varnish, whereas when combined with capillarity it produces duricrust and salt accumulation in the mantle. Erosion surfaces which stretch horizontally for long distances in this area are perfect sites for water to soak and for salt residues to accumulate by capillarity. Salt crystals are seen by the naked eye whenever the mantle of these erosion surfaces is turned over. This is believed to be the main reason for these surfaces being among the most desolate and devoid of vegetative cover.

In hard silicified limestone pebbles which are scattered at these surfaces, soaking is not complete and the water that slips over the surface produces, by selective solution, characteristic rilling. Rill stones (Walther, 1900) are strewn on erosion surfaces where creep and deflation of finer material are the dominant forms of transportation; the pebbles therefore remain unmoved for long times. The rilling is in the form of

numerous well packed grooves, seldom more than 1 mm. in breadth or depth. That this rilling is due primarily to water action is demonstrated by the fact that the grooves are rarely found in straight lines but are meanderine and highly twisting. In rare cases solution on some of these pebbles produces instead of grooves oval depressions some 4 mm. in length and 3 mm. in breadth which can be later polished and steepened on one side so as to give an asymmetrical shape to the cavity. Solution is believed to be of primary importance in forming these rills because the grooves are just as well developed on the undersurface of the pebbles and in the buried parts as on the exposed surfaces.

Rock weathering in this area has been usually attributed to temperature fluctuations. Although there are features in the area that cannot be ascribed but to this factor as the presence of certain flint pebbles that are seen split into pieces along perfect lines, there is indication, however, that temperature fluctuations are not of great effect in weathering. Experiments conducted along the lines of Griggs (1936) on typical limestones of the area showed that repeated heating and cooling in dry ovens did not affect the material. It is therefore concluded that weathering in the area is primarily produced by moisture wedging probably aided by processes of secondary mineral formation.

Weathering in Limestone. The country east of Helwan is exclusively built of limestones. The marls described in the stratigraphic sections of the area are mostly what American geologists call argillaceous limestones having a clay ingredient of less than 20 %. There is one layer of intraformational conglomerate in the middle of the section with limestone boulders and calcareous matrix.

The limestones of the area are of different kinds. They weather into a variety of forms. It is believed that the multitude of weathering forms under the same climatic conditions depends on four main factors :

1. The hardness of the rock, usually a function of its compactness, and or the amount of silicification or dolomitization it underwent.

2. The composition of the rock with regard to its lateral homogeneity or heterogeneity. Some limestone beds continue for long distances

with the same composition, while others, either through penecontemporaneous or postdepositional changes, alter their composition even over short distances. This change does not necessarily entail a lithofacies change but is only a minor alteration seen only by the experienced observer in the field. The heterogeneity of the bed may be due to the addition of chemical deposits such as iron oxides or salts or to the concentration of more detritus in certain localities of the bed.

3. Fissures in the rocks including pores, joints, cracks and other fractures even to the minutest capillaries. Since limestone rock is very susceptible to solution, the fissures are of great consequence in the final weathering form of the rock. Permeating waters dissolve the limestone and deposit vienlets of calcite or other foreign matter, such as gypsum, and produce wedging effects that destroy the rock.

4. The physiographic and topographic position of the rock : Rocks found on cliffs behave differently under the same weathering conditions from the same rocks found on the top of an erosion surface etc.

Taking these four broad factors as a basis for surveying the different weathering forms, one can classify the multitude of weathering forms of limestone met with in the area east of Helwan into the following broad categories :

1. *Chipping* (fig. 1, pl. I) is a weathering form of limestone known in varieties of hard, impervious and homogeneous rocks characterized by the presence of well-spaced cracks (between 1 and 20 cms apart). This weathering form obtains in exposed surfaces, usually on the top of slopes, where cracks produced by wedging are not filled by precipitation, or healed under compaction. This type of weathering produces highly angular chips usually as big as a hand in size, but sometimes as big as 1 m. in length or as a small as 2 to 3 cms in length. Further chipping may result later along lines of least tension. In fig. 1, pl. I, it is obvious that some of the chipping planes are primary while others are secondary due to readjustment along lines of weakness to the new fabric of the dislocated rock.

2. *"Cleaving"* (fig. 2, pl. I). This a special kind of chipping that takes place along straight planes usually parallel to the bedding. This is common in argillaceous limestones and may be due to the rhythmic and imperceptible alternation of lamina with varying detrital ingredient. Although the mechanism of both chipping and «cleaving» is the same, the origin of the fractures of the rock is different. In cleaving the fractures are due primarily to a process of deposition, while in chipping they are made through compaction.

3. *Flaking* (figs. 3, 4, pl. II). This is the most common of all weathering forms of limestone. It occurs in pervious limestones with or without cracks. When the cracks are found, they are always post-depositionally filled with a precipitated salt. In this type of weathering the water soaks uniformly rather than seaps through cracks and fissures. The effect of this is the increase in volume of the hydrated surface layer and its ultimate release in flakes sometimes held on the surface by the binding action of salts ejected by capillary action. These flakes when removed mechanically or by the action of gravity disintegrate into a sandy material. A special kind of this type of weathering produces the duricrust on limestone beds. When layers of such limestone extend laterally uniformly for a long distance a smooth surface is produced. Smooth surfaces are noticed in most reentrants along cliffs since these layers are among the fastest to retreat. When the weathering, on the other hand, affect heterogenous beds, flaking is seen in the form of detached, more or less spheroidal shapes.

4. *Solution*. Hard limestone beds whose topographic position permits water to accumulate in hollows or lows before complete soaking takes place show numerous solution features (fig. 5, pl. III) including midget caves. These solution features are never on the scale known in karst topography. Solution can take place also along scarps where the soaking water may spill over from a weak exposed point. This type of weathering produces hollowed rocks with tops hardened by chemical processes, and exposed hollowed sides. Consider fig. 6, pl. II where this process is amply demonstrated and the effect of solution quite obvious, and fig. 7, pl. III where a similar process is believed to have produced

this characteristic weathering in the blocks of the old dam of sad el-Kafara built some 10 kms to the east of Helwan by the Ancient Egyptians.

Although the above types of weathering are characteristic and distinct, it is possible that the same bed of limestone would undergo different types of weathering in different parts. Furthermore, two types of weathering can occur at one and the same locality, for example chipping and flaking. However the weathering, of each bed is characteristic and it is possible to base correlations, at least on a local scale, upon it.

Pedestal rocks : These are known to occur in this area in the form of small tops (seldom exceeding 2 metres in height) whose tapering points rest always on a hard silicified limestone bed. It is believed that this shape is due to the soaking water whose action is more intense in the lower part of the structure since it is concentratal by being hindered from percolating into the hard layer beneath (fig. 3, pl. II). Wind contributes in the shaping of these structures inasmuch as it removes all debris resulting from the weathering. If, however the rate of disintegration exceeds the rate by which the wind removes the debris, as is the case in structures made of friable marly beds, a cone shaped structure develops (fig. 8, pl. IV). That pedestal rocks are primarily due to solution is demonstrated by the fact that some rocks assume perfect right angle surfaces; these surfaces being determined by some old gypsum-filled jointing planes (fig. 9, pl. V). If wind were the primary factor in the shaping of these structures, gypsum could not have acted as a surface at which the mechanical action of wind stopped since gypsum is softer than limestone. On the other hand, gypsum, due to its small solubility, can offer a surface of resistance to solution.

Rates of weathering. A remarkable archeological site, is the dam built in the third or fourth dynasty, and which was first discovered by Schweinfurth (1922) and recently described in detail by Murray (1947) and Hellström (1952). This dam was built from blocks of limestone excavated from a nearby quarry. It is constructed in thirty-two steps each of an average of thirty to forty cms in height. The average dimensions of the blocks are some sixty by forty cms in length and breadth respectively. These

blocks are highly weathered and hollowed (fig. 7, pl. IV). Apparently the hollows start as minute cracks somowhere in the lower part of the abutting surface of the block and grow until they are large relative to the size of the block. The tops of the blocks are capped by a thin layer of hard crust that adds to the hardness of this part; this crust is the last section to fall. According to Hellström these hollows are due to wind action, while the crust on the top surface is due to «rain and subsequent chemical action». The idea that wind is the primary factor in the making of these hollows cannot be accepted because these hollows are not in the position most exposed to wind action. On closer examination, the walls of the hollows are found to be not polished but weathered in broad dull falkes that fall easily and which, as explained above, are due to the effect of soaking water. On this assumption the hard crust on the surface and the hollowing are attributed to one process rather than two working simultaneously on the same block. A similar process in the field is seen in limestone beds in which soaking water finds its way out from the sides, enlarging the cracks through which it runs out, and leaving the top a layer hardened through evaporation and concentration of less soluble salts.

Some of these hollows in the area exceed forty cms in depth, but the majority average some thirty cms. The retreat of any outcrop through this process of weathering alone (which is seldom the case) is some six to eight cms per 1000 years.

Wadi Beds. Wadi beds in the area are mostly covered with a thin veneer of alluvium and or gravel. Whenever the wadi bed is made of the hard silicified limestone and is topographically high, the bed is bare, smoothly polished and sometimes grooved in longitudinal channels in the direction of the water current (fig. 10, pl. V). Whenever a source is available, boulder accumulation due to the influence of gravity takes place along the sides of wadi beds, while the middle of the wadi bed is cleaned free of gravel (fig. 11, pl. VI). However, great stretches of wadi beds completely covered with gravel from different sources is noticed only in topographic lows relative to the immediate downstream part. In such areas boulders that have travelled different distances are trapped;

that is why the boulders are of varying degrees of rounding (fig. 12, pl. VI).

While hard and silicified beds of limestone fall, due to the effect of gravity, along jointing planes to contribute to the gravelly appearance of the sides of wadi beds the softer limestone beds disintegrate quickly into sandy material that is distributed by water action along most wadi beds (fig. 13, pl. VII) in the form of a thin veneer of alluvium. Fill small terraces up to 1 $\frac{1}{2}$ m. high are known to exist all along wadi floors (fig. 13, pl. VII). They are usually better developed in areas where soil binding plants flourish. It is probable that similar terraces would have bounded most wadi beds had it not been for the effect of grazing in most desert areas in Egypt.

Even in wadi beds where no continuous and well defined terraces border the sides there is evidence that degrading is now the rule in the once aggrading wadis. Strewn along the sides of wadis are many plants, *Achillea fragantissima,* with exposed roots of 50 to 120 cms long indicating that a soil of this thickness has been removed in recent years from the wadis (fig. 14, pl. VII). There is an indication that alluvium movement is relatively common; the distribution of alluvium is usually adjusted to the effect of the last few torrential rains that had affected the area.

Geomorphology. The area east of Helwan is one of recent uplift with numerous incised meanders, the most famous of which is Wadi Hof. The uplift affected a mature old surface with the result that the main tributaries and streams incised their valleys deep into a typical, though less impressive, box-canyon type. Lesser tributaries, however, failed to cope with the uplift with the result that they were graded to newer base levels determined by resistant silicified limestone beds. Lateral planation caused extensive horizontal erosion surfaces with the hill side scarps on the top retreating parallel to the original slope. In some instances stages nearing maturity developed on these surfaces. It is not infrequent to meet in the area many mushroom rocks and buttes representing the end products of a disappearing landscape (fig. 15, pl. VIII).

The area east of Helwan is composed of Upper Lutetian limestones

with a total thickness of some 200 metres of alternate layers of hard resistant limestone and soft white or rarely brownish limestones. The strata are more or less horizontal with a slight dip towards the west. In a section facing the north side of Sad el-Kafara there are not less than six hard resistant beds of limestone which mark excellent free faces (Wood, 1942) of some 1/2 to 1 m. thick (fig. 16, pl. VIII and fig. 17, pl. IX). They are separated from one another by softer beds of limestone of varying thicknesses from 5 to 15 ms. The hard limestone beds, as previously mentioned, are the most important elements upon which the geomorphology of the area is based because they represent a series of successive local base levels to which the land above them was graded. These are the levels at which downcutting was hampered causing the energy of weathering processes to be directed towards lateral planation (fig. 18, pl. IX). The erosion surfaces thus developed are in this area five in number. They are from the highest to the lowest : the Hof surface of about 300 m. high, the Garawi surface of about 210 m. high; the Observatory surface of about 140 m. high; the Helwan surface of about 100 m. high and the Cement factory surface of about 60 m. high. Some of these surfaces are very extensive and remarkably horizontal; they are veneered by a thin layer of alluvium and gravel. The gravel is usually the result of the chipping of the hard limestone bed that makes the undersurface. It is on these surfaces where soaking is at a maximum, that rill stones, salt accumulation in the mantle and desert varnish are universal. Here also deflation is at a maximum and wind action produces the dreikanters and other edged stones common on these surfaces. These surfaces are covered with a residual gravelly carpet, the perfect erosion pavement. It is a poorly sorted lose rock with a yellowish fine grained matrix.

Of particular interest are some split pebbles that are described in the literature as due to thermal action. These pebbles are split along one line into two pieces and lie next to each other along the splitting line. They are common on erosion surfaces. Vanderhoof (1948) found split pebbles that he estimated to have lain next to each other for over 20.000 years as indicated by associated flint impliments which certainly show that sheet flood erosion did not take place in Egypt for the length

of that time. Erosion surfaces in this area are convex in section (fig. 19, pl. X). They correspond to the waxing slopes (Wood, 1942), the elements at the top of hill-sides. It is obvious that the convexity of the waxing slopes is moulded by soil creep as suggested by Davis (1892) and recently attested by King (1953).

Hillslope elements. While the erosion surfaces described above represent the convex waxing slopes of the hill sides of the area, the other elements of the slope are typical of arid and semi arid climates. They are steep and with very little rounding. The free face is well developed and is represented by the outcrops of the hard resistant limestone beds whose top makes the erosion surfaces. This face is followed by the debris slope which is of considerable importance in the area under discussion. The declivity assumed by the debris slope is controlled by the size of the fragments. If the material contributed from upslope is gravelly or in blocks, steep talus cones of extensive dimensions develop (fig. 20, pl. X). When the material contributed is sandy, the debris slope declivity is less steep (fig. 13, pl. VII). In all the district the hill slopes exhibit a remarkable likeness of gradient which in the words of King (1953) « could be so only if the hills large and small, had maintained throughout their erosional history a remarkably constant angle of slope». There is no doubt, that the district under discussion is a remarkable test for the theory of « stable abgle of slope». What could be a better proof for this parallel retreat of slopes and scarps than the numerous photographs that accompany this note?

The agencies that affect the retreat of a hillside scarp are weathering, downhill movement of debris under gravity (fig. 20, pl. X), and the attack by gully heads of numerous small streams or rills which correspond, in a measure, to the free face. There can be no better way of explaining the mechanism of this latter and most important of processes than by the accompanying photograph (fig. 19, pl. X).

The waning face is always very faint, small and poorly developed, the district being one of recent uplift and youthful physiography.

The major geomorphological features are mainly due to the wet climate in the past; while the arid conditions contributed much to the lowering of land and the retreat of slopes. Although neither the wet nor the arid climates continued for any length of time as can be attested by the fact that no genuine karst topography or a topography solely made by arid conditions has developed, the wet climate and the occasional cloud bursts of the arid climate are responsible for the dissection of the area, while moisture during the arid periods produced the characteristic weathering forms. Wind effect is very minor, and apart from its role in transport is almost limited to the polishing of cliffs and boulders and the formation of edged stones.

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Fig. 1 : Weathering of limestone by chipping.

Fig. 2 : Weathering of limestone by "cleaving".

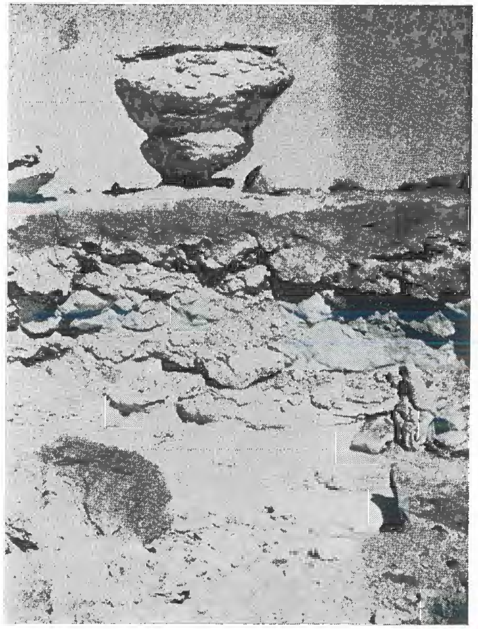

Fig. 3 : Mushroom rock standing on Helwan erosion surface. Lower bed shows weathering of limestone by flaking.

Fig. 4 : Weathering of limestone by flaking.

FIG. 5 : Solution in limestone (wadi Garawi).

FIG. 6 : Weathering by solution in limestone.

Fig. 7 : Some blocks from Sad el-Kafara dam built 5,000 years ago showing hollows believed to be excavated by solution and polished by wind. Notice stages of growth of hollows from lower left to lower right to upper and more common type.

Fig. 8 : Cone-shaped erosion remnant.

Fig. 9 : An erosion remnant with sides determined by jointing.

Fig. 10 : Wadi Garawi bed with grooved floor. Handle of cane points to direction of water flow.

Fig. 11 : terraces on the side of wadi Garawi with plant cover.

Fig. 12 : Wadi bed with boulder and gravel showing different degrees of rounding and polish.

Fig. 13 : Fill terrace with plant cover (wadi Garawi). Notice gentler angle of debris slope in the background.

Fig. 14 : Exposed roots of *Achillea fragantissima* showing thickness of soil washed in Recent time.

Fig. 15 : Buttes at the entrance of Helwan showing different stages of their development.

Fig. 16 : Panorama of southern bank of wadi Garawi, an incised meander, showing repeated free faces (made of hard beds) and debris slopes with characteristic talus cones.

Fig. 17 : Panorama of northern bank of wadi Garawi topped by the Garawi erosion surface.

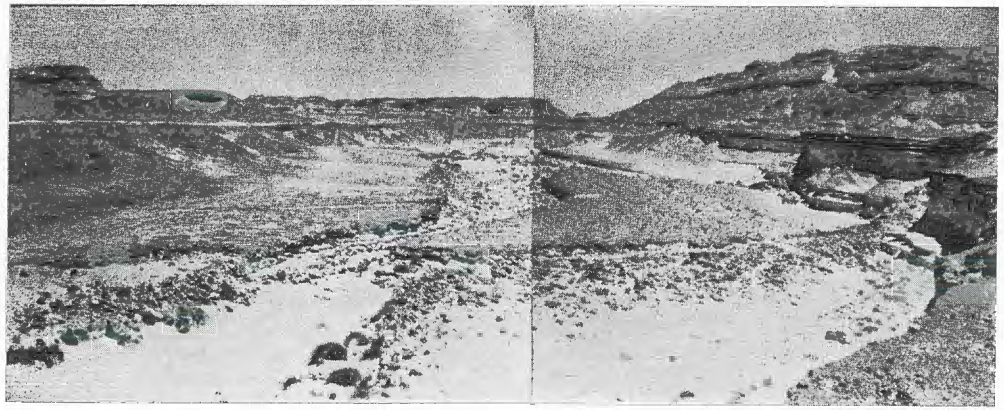

Fig. 18 : Panorama of wadi Garawi downstream of Sad el-Kafara showing four different erosion surfaces.

Fig. 19 : Lower left showing birth and retreat of gully heads—Notice parallel slopes and convex waxing slope.

Fig. 20 : Landslide on a hillside scarp with multiple free face and debris slope.

GÉOGRAPHIE ET PAYSAGES AFGHANS

QUELQUES DONNÉES GÉOGRAPHIQUES ET HISTORIQUES SUR QUELQUES LOCALITÉS [1]

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L'Afghanistan, comme on le voit sur la carte géographique d'Asie, a une forme semblable, comme nous le disons nous-mêmes, à une peau d'astrakan, ou comme le disent parfois les étrangers, à une raquette de tennis, dont la manche se prolonge à travers le Pamir vers le Turquestan chinois. Il occupe physiquement la moitié orientale du plateau de l'Iran ; l'Afghanistan est un plateau contenant en lui-même un haut plateau, celui de Pamir formant Bani-i-Donya ou le « Toit du Monde».

L'Afghanistan a une superficie de 750.000 kilomètres carrés, un peu plus grand que la France ou l'Allemagne d'avant-guerre. L'Afghanistan physiquement et ethniquement possède des limites naturelles. Par le nord, il est limité par la rivière Amou-Darya, Djayhoun des géographes arabes. Le confin de l'est et du sud-est est limité par la Rivière de Sind ou Ab-é-Sind ou Abasain ; c'est l'Oxus des géographes classiques, grecs et Sindhou des hymnes védiques et Hindous de l'Avesta d'où le nom de Hind est sorti et s'applique à tout le territoire au delà de la rivière et à tout le subcontinent de l'Inde. Ces deux grandes rivières, descendant du Haut Plateau de Pamir, encadrent le pays des Afghans qui forme ainsi une sorte de grande Mésopotamie. A l'ouest, une dépression énorme région marécageuse d'Hamoun, ancienne mer desséchée et Dacht-é-Louth, désert saharéen démarquent le pays afghan de la Perse ; et dans

[1] Conférence donnée à la Société de géographie d'Egypte le 27 avril 1954.

d'autres termes, sépare les deux moitiés orientale et occidentale du Plateau iranien.

L'Afghanistan est un pays de hautes montagnes. L'Hindou-Kushe constitue l'épine dorsale de notre pays. C'est au Pamir qu'il est joint avec l'Himalaya et Karakorum formant le Haut Plateau au cœur de l'Asie. L'Hindou-Kushe est en quelque sorte la contre-balance de l'Himalaya, l'un s'inclinant vers le sud-est en haut du sub-continent indien et l'autre se prolongeant dans la direction opposée vers le sud-ouest en territoire afghan. La chaîne de l'Indou-Kushe a une hauteur moyenne de 4.000 mètres. Le point culminant Taratch Mir atteint 6.000 mètres de hauteur. Au nord de Kabul, cette chaîne se divise en deux branches. La chaîne secondaire porte le nom de Koh-é-Baba et se prolongent toutes les deux parallèlement dans la direction sud-ouest. Les aryens de l'époque Avestique ont reconnu l'Hindou-Kushe sous le nom de UPAIRISSENA qui veut dire « plus haut que le vol de l'aigle ». Le même nom raccourci est devenu APARSIN, en langue pahlavi dans le Bundahish. Les géographes classiques grecs appelèrent la partie occidentale de la même chaîne PARAPAMISE et Ptolomé, le géographe gréco-égyptien au cours du IIe siècle de l'ère chrétienne, s'inspira du même nom et la région dite PAROPAMISADAI par lui identifiée avec la partie orientale de l'actuelle province de Kaboul. En Afghanistan, nous avons deux grandes chaînes de montagnes (groupes), la Montagne Blanche et la Montagne Noire réciproquement au sud-est et au nord-ouest. SPITA-GAONA-GAIRI en avestique, SPIN-GHAR en Poshtou et SAFID-KOH en persan est la chaîne qui parallèlement au cours de l'Indus constitue la première barrière afghane vers la plaine de Pandjab. La chaîne Noire se trouve en face le long de la vallée de Konar encadrant avec la première la plaine de Nangharhar ou actuelle Djelalabad.

Le groupe opposé des Monts Blanc et Noir se trouvant au nord-ouest encadre la vallée de Hari-Rand ou actuelle province d'Herat. En Avesta, ces deux montagnes sont mentionnées sous les noms de SIAMAKA et WAFRAYANT qui veut dire respectivement le Mont Noir et le Mont Neigeux.

Les chaînes de montagnes constituent deux massifs rocheux en Afghanistan : le massif du nord-est au Pamir et le massif central au Hazaradjat.

L'Hindou-Kushe avec ces deux massifs est un véritable château d'eau.

Du haut plateau de Pamir, quatre grandes rivières torrentielles, l'Oxus, l'Indus, Syr-Dorya et Yarkande, avec leurs affluents, descendent sur les quatre coins de l'horizon dont les deux premières encadrent l'Afghanistan physique et ethnique.

Du massif central, un autre groupe de rivières s'épanouissent encore dans les quatre directions.

Les eaux qui prennent source sur les deux versants de l'Hindou-Kushe atteignent partiellement l'océan Indien. Le Kaboul, avec ses affluents principaux, le Pardjchir et le Konar se versent par l'Indus à l'Océan Indien. Les eaux du versant nord de l'Hindou-Kushe arrosent la plaine de la Bactriane et n'atteignent pas l'Oxus, sauf le Kunduz. L'Oxus, elle-même, se jetait il y a deux mille ans dans la mer Caspienne, depuis, elle a changé de cours et actuellement, elle se verse dans la mer d'Aral. Le troisième groupe qui prend source du Massif Central, sous forme d'un éventail gigantesque s'épanouit vers le sud-ouest et le bras principal l'Hilmand « Le Nil de l'Afghanistan » se jette dans le Hamoum, ancien fond de mer; dépression dont le niveau est plus bas que la mer.

En bref, l'hydrographie de l'Hindou-Kushe est très simple; au nord, les eaux vont à l'Amoudaria, au sud-ouest à l'Hilmand et au sud par la rivière de Koboul à l'Indus.

L'Afghanistan, en dehors des hautes cimes et des solitudes semi-désertiques de l'Hindou-Kushe, consiste de trois glaciers :

1° Au nord : l'immense plaine de la Bactriane.

2° A l'ouest et au sud-ouest : la plaine d'Hérat et Seistan, Sadjestan et Hérai, des auteurs arabes l'Antique Arie et Dzangian.

3° Au sud et au sud-ouest, la région de Ghazni-Kandahar, Zaboul ou Zaboulistan du haut Moyen-Âge; l'antique Arachosie et la région de Kaboul et Djelalahad; Parapamisades des Grecs et Kapis des voyageurs chinois et l'antique Ningrahar qui correspond à la partie occidentale du Gandhara.

L'Afghanistan, pays continental et de hautes montagnes, a un climat rude, sec, très sain. Quatre saisons bien définies, neige abondante, pluie

printanière. Djélalahad et Kandahar jouissent d'un climat doux en hiver. La première qui se trouve à une distance de 150 kilomètres à l'est de Kaboul est le quartier d'hiver des habitants de la capitale.

L'Afghanistan est peuplé de 12 millions d'habitants. Plus de 7 autres millions afghans vivent au delà du « Durrin Ligne » et le cours de l'Indus. Ce sont les tribus montagnardes vivant dans les plis du Mont Seleiman, d'où les afghans en général étaient reconnus sous le nom de Seleimanis par les auteurs arabes.

Il y a des centaines de milliers d'afghans aux Indes. Ce sont les nomades et les commerçants. 75 % des habitants de l'Afghanistan vivent par l'agriculture. 8 % sont nomades qui sont en mouvement suivant les saisons entre le massif central et la plaine du Pendjab. Nous n'avons pas encore de grandes villes. Kaboul, la capitale du pays, atteint à peine 300.000 habitants. Les autres villes Kandahar, Herat, Mazar-é-Chérif ne dépassent guère 50 à 60.000 habitants. Les habitants de l'Afghanistan sont en général dispersés dans les villages. Il y a une trentaine de milliers de Qalehs et villages dans le pays. L'Afghan est originairement Aryen. La haute vallée de l'Oxus et Sardarya, actuel Farghana est identifiée par un grand nombre de savants par Aryana-Vego, homme primitif du clan Indo-iranien. Deux sources principales aryennes, les Vedas et l'Avesta nous comblent de renseignements précis à cet égard. Les 16 contrées sacrées créées par Ahura-Muzda et mentionnées dans le Vendidade composent les provinces actuelles de l'Afghanistan échelonnées tout autour de la chaîne de l'Hindou-Kushe. Une grande partie des sédentaires agricoles sont des Tadjeks de même race que les afghans. C'est ainsi que le pays fut reconnu dès le III^e^ siècle av. J.-C. sous le nom d'« Ariana », pays des Aryens par les auteurs grecs Eratosthènes et Strabon. Les afghans se donnent eux-mêmes le nom de Pashtoun dont le pluriel est Pashtana ou Pakhtana. Ce nom, on le voit pour la première fois dans les hymnes védiques sous forme de Pakhta. Hérodote mentionne le nom de Pactys ou Pactius qui est le même que Pakht et Pakhtoun. Pactica, le pays des pactys après vingt-deux siècles existe encore sous forme de Pakhtounkhoi. Comme l'Afghanistan se trouve au carrefour du continent asiatique, depuis les temps préhistoriques, des peuplades diverses, à la suite des immigrations et les expéditions des grands conquérants des Indes, se sont versées chez nous. Les Grecs, les Scythes, les Koushans, les Hephtalites, les Turcs, les Arabes se sont mêlés avec la race autochtone du pays. On distingue encore des éléments turkmends au nord et des éléments mongols au centre du pays.

La race afghane est une race montagnarde virile et forte, alerte et vive, les afghans sont de haute et robuste stature, ils ont le teint blanc foncé, et sont épris de liberté, avec un sens inné de l'honneur individuel, familial et national.

L'Afghanistan est un pays agricole. La terre afghane est fertile, l'eau est abondante. Seulement comme nos rivières ont creusé leurs lits, nous ne pouvons pas les utiliser beaucoup. Jusqu'à la veille des invasions destructives des Mongols, on jouissait d'un grand système de canalisation qui distribuait l'eau d'une manière efficace et rationnelle dans tout le pays.

A la suite de la destruction systématique des barrages et des canaux, et la négligence des temps post-mongols, une grande partie du pays est devenue désertique ou semi-désertique. Par exemple, le Seistan afghan, le pays étendu entre Harirand et Arghandabe, le Sadejstan des géographes arabes était considéré comme le « Jardin d'Asie ». De nos jours encore, et sur 200 kilomètres le long de Hilmand entre Ghirishke et la frontière persane, des ruines successives des villes se font voir. Le vent de soixante jours qui souffle du côté de la mer Caspienne fait sortir des couches de sable de troncs d'arbres énormes. Cela prouve à quel degré le Seistan était vert et prospère. La même situation existe au nord de l'Hindou-Kushe dans la Bactriane.

Les céréales, comme le blé, l'orge, le maïs, sont abondants. Le blé pousse jusqu'à une altitude de 3100 mètres. L'Afghanistan est connu depuis des siècles par ses excellents fruits. La pomme, la poire, la cerise, l'abricot, la grenade, la pêche se trouvent partout. Nous avons une grande variété de raisin dont l'espèce dépasse 30 sortes. Hérat, Kandahar et Kaboul sont les trois principaux centres de production. On en fait sécher d'importantes quantités pour la consommation locale et pour l'exportation, car le fruit sec et frais constitue une des grandes factures d'exportation. Nous avons d'excellentes pastèques et melons, le dernier est d'une célébrité mondiale. Au nord de l'Hindou-Kushe, il en pousse

à l'état sauvage. Le coton, la betterave et la canne à sucre sont d'autres productions agricoles. On exporte du coton afghan en Russie et aux Indes. On en utilise dans le pays pour les fabriques de textile. La récolte de la betterave est entièrement utilisée pour la fabrication du sucre. De la canne à sucre, on fabrique actuellement suivant la méthode locale et primitive, une sorte de sucre jaune qu'on appelle « Gor». L'agriculture en Afghanistan n'est pas encore mécanisée. De grands progrès de constructions de barrages et canaux d'irrigation sont envisagés et même réalisés dans l'Afghanistan méridional.

L'Afghanistan est propice pour l'élevage des animaux. Le nord Afghan, l'immense plaine de la Bactriane est le centre de l'élevage de troupeaux de moutons, sortant d'Astrakhan, dont le pays est un des grands exportateurs. On fait aussi l'élevage des troupeaux de vaches. Nos nomades ont beaucoup de chameaux qui constituent le moyen essentiel de transport. N'oublions pas les chevaux dont la race est très célèbre. Deux de nos provinces Qataghan et Mazar-é-Charif constituent deux grands foyers d'élevages de chevaux.

L'Afghanistan, administrativement, est divisé en sept grandes provinces (Walayats) et six petites provinces (Houkoumat-é-Ala). Les grandes provinces suivant leurs étendues sont subdivisées en Houkoumat-é-Kalan. Les gouverneurs des grandes provinces appelés : Naib-é-Hakouma, ceux des petites provinces sont appelés : Naib-é-Hakouma, ceux des petites provinces sont appelés : Hakein-é-Kalan.

Les grandes provinces sont les suivantes :

1) Kaboul (le centre est Kaboul);
2) Kandahar (le centre est Kandahar);
3) Herat (le centre est Herat);
4) Mazar-é-Chérif (le centre est Mazar-é-Chérif);
5) Qataghan (le centre est Baghlan);
6) Province d'Est (le centre est Djelalabad);
7) Province du Sud (le centre est Gardaiz).

Les petites provinces ou Hakomat-é-Ala sont :

1) Badakhshan (le centre est Faizabad);

2) Maimana (le centre est Maimana);
3) Farah (le centre est Farah);
4) Guéréshk (le centre est Guéréshk);
5) Ghazni (le centre est Ghazni);
6) Parvan (le centre est Tcharikar).

La province de Kaboul a 2 Hokoumat-é-Kalan
a) Logar; *b*) Daizangui.
La Province de Kandahar a 2 Hokoumat-é-Kalan
a) Qalat; *b*) Oruzgan.
La Province d'Herat a 3 Hokoumat-é-Kalan
a) Ghorat; *b*) Badghissat; *c*) Ghoriyan.
La Province de Mazar-é-Charif a 3 Hokoumat-é-Kalan
a) Samangan; *b*) Balkh; *c*) Shéhérghan.
La Province de Qataghan a 3 Hokoumat-é-Kalan
a) Pul-é-Khamri; *b*) Taluqan; *c*) Qunduz.
La Province d'Est a 2 Hakoumat-é-Kalan
a) Kunar; *b*) Laghman.
La Province du Sud a 2 Hokoumat-é-Kalan
a) Orgune; *b*) Khost.

D'après ce que je viens de décrire plus haut, l'Afghanistan, du point de vue du paysage naturel, est un pays de contraste. Il y a des cimes de montagnes qui atteignent 6.000 mètres d'altitude. Par contre, il y a des régions comme le Hamoun (Région lacustre dans le Seistan qui est plus basse que le niveau de la mer). Dans les régions montagneuses, des mètres de neige tombent, tandis que d'autres régions comme Kandahar et Djelalabad n'en reçoivent rien. Ainsi le climat varie énormément d'une distance à une autre, entre Kaboul et Djelelabad, centre de la province de l'est, il n'y a que 150 kms de distance, 5 heures d'auto. Lorsqu'en hiver, Kaboul est enfouie sous une couche très épaisse de neige (40 à 50 centimètres), par contre à Djelalabad on trouve de la verdure et des fleurs partout.

En général le paysage Afghan offre un relief montagneux, aux horizons extrêmement variés, le plus souvent abrupt sauf dans deux provinces de

l'est et du sud où les moussons se suivent presque et les parois rocheuses sont couvertes de forêts de sapins et de châtaigniers et de bois blanc. Nourestant, au nord de la province d'est et Djadran, dans celle du sud, sont les plus caractéristiques à cet égard. Les montagnes à Nourestant sont tellement boisées qu'il est difficile de se frayer un chemin même pour le piéton. Les vignes poussent jusqu'au dessus des arbres fruitiers.

La population de cette région est convertie à l'islam seulement depuis 80 ans, les voyageurs et les touristes rencontrent surtout en printemps et en automne des nomades un peu partout en mouvement sur les routes. Des centaines de milliers de nomades vivent encore chez nous. Ce sont en général des tribus car il ne faut pas oublier que la base primitive de la vie sociale afghane est celle des tribus. Nous avons encore de nos jours des centaines de tribus dont la généalogie remonte aux temps fabuleux. Ces tribus ont leur chef et leur code de vie sociale, Djergah (réunions) dans lesquelles ils résolvent leurs problèmes respectifs dont la portée ne dépasse pas le cadre de la tribu. L'Afghanistan, pays de cultures, de civilisation, de haute antiquité, est un pays neuf. A côté d'anciens vestiges de différentes cultures, religions et civilisations de siècles écoulés, on voit les marques de la vie moderne, vers laquelle le peuple et le gouvernement se dirigent résolument.

L'Afghanistan, depuis les temps préhistoriques, environ depuis 3.000 ans jusqu'à nos jours, a vécu de nombreuses civilisations. Entre ces cirques de montagnes, c'est une sorte de creuset où toutes les cultures et toutes les religions, toutes les langues, et tous les peuples du Proche et Moyen Orient se sont enchevêtrés, mêlés les uns aux autres. C'est là que l'Iran, l'Inde, la Chine et l'Asie Centrale se rencontrent. C'est là que védisme, brahmanisme, zorastrisme, bouddhisme, manéchéisme, nestorisme et enfin l'islamisme laissent depuis des siècles millénaires, des couches superposées, l'une prenant la place de l'autre.

C'est ainsi que l'étude de nomenclature de localités en Afghanistan est très intéressante pour les géographes, les historiens, les géologues, les ethnologues, les archéologues les philologues. Il y a de nombreuses localités qui portent plusieurs noms, chacun étant le souvenir d'une période distincte de la littérature et de l'histoire.

L'étude des noms géographiques de ces localités suivant les périodes historiques et littéraires, offre un champ très vaste et exige de brosser l'histoire plusieurs fois millénaire de l'Afghanistan, et ces noms peuvent nous illustrer le souvenir des temps écoulés depuis l'apparition des Aryens sur la scène, jusqu'à nos jours.

Balkhika, à l'époque védique, Bakhdi, à l'époque avestique sont deux formes du nom de Balkh, la ville fameuse au nord de l'Hindou-Kushe. Cette même ville dans la littérature pahlavique est Bakhl ou Bakhl-é-Bamique. Les géographes arabes en ont fait Balkh-ul-Hussna. Nos premiers historiens des premiers siècles de l'Hégire ont changé la forme pahlavique au persan : Balkhé-Bami. Encore cette même cité était connue à l'époque achéménide (v[e] siècle av. J.-C.) par le nom Bakhtrish. Les grecs classiques ont en fait Bacte, et Bactriane pour la ville et la province. Bakhtar et Balkh sont les noms que nous employons même actuellement. Cet unique exemple est très évoquant pour vous donner une idée de l'antiquité du pays afghan et de la variété vaste de ses périodes littéraires. C'est à peu près ainsi pour un grand nombre de localités autres.

La rivière de Kaboul est Kubha dans les hymnes védiques Vaêkereta est le nom avestique. Les grecs l'ont appelé le Kophin. Ptolomé, le géographe gréco-égyptien au cours du II[e] siècle de l'ère chrétienne l'appelle Karoura (plutôt appliqué à la ville). Dans la littérature pahlavique, nous trouvons la ville de Kaboul sous le nom de Kapol, d'où vient le nom de Kaboul.

Bamiyan, la fameuse vallée de l'ouest de Kaboul où se trouvent les plus grandes statues de Buddha (53 et 35 mètres de hauteur) est mentionné dans les sources chinoises et pahlavies sous forme de (Faw-yan-na) (Fan-yan) Bamikan, et enfin Bamiyan.

A Kandahar, la rivière naissant près de la ville fut connue à l'époque avestique sous le nom de Harahvaiti. Alexandre y fonda Alexandrie, c'est l'Alexandrie d'Aracausie des grecs. Les écrivains arabes mentionnent la ville Arrakhadji d'où est dérivée la forme Pakhad. On dit que le mot Kandahar dérive du nom du roi Gandophar qui au cours du I[er] siècle av. J.-C. fut le fondateur de la ville.

Ainsi, on peut étudier des centaines de noms de localités dans différentes périodes de l'histoire de l'Afghanistan. Ce n'est plus le cas ici, c'est un sujet à part et doit être traité dans une étude à part exclusivement réservée.

HABITAT FACTORS AND PLANT DISTRIBUTION IN EGYPT

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CONTENTS

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I. INTRODUCTION

Egypt is divided into seven Phytogeographical regions, which are :

1.	Desert region	D	5.	Gebel Elba region	GE
2.	Mediterranean region	M	6.	Nile region	N
3.	Red Sea region	R	7.	Oases region	O
4.	Sinai region	S			

These different regions support more than 1800 species. Some of the species are considered to be constant *i. e.* found in five or more of these regions. These are only 42 spp. or 2.2 % of the Egyptian flora. Other species are considered to be indifferent *i. e.* found in any region but not characteristic to it. These are 404 or about 20 % of the Egyptian flora. Exclusive species are those found in two regions, these are 472 or 26 % of the total flora. The absolutely exclusive species are those confined to one region, these are 835 spp. or 48 % of the Egyptian flora (Hassib 1951).

Table (1) presents the distribution of the different species in the phytogeographical regions of Egypt and the number of the indigenous ones.

TABLE (1)

Region	Spp.	Percentage	Indigenous
D	757	41.5	125
M	825	50.9	300
R	31	1.7	11
S	527	29.0	134
G. E	231	12.7	121
N	543	29.9	126
O	335	18.4	26

Table (2), presents the frequency of the different species in the different regions, showing the percentages of the absolutely exclusive, indifferent and constant species (Hassib 1951).

TABLE (2)

No. of spp.	% of total	No. of regions	
835	48 %	1	absolute exclusive
472	26	2	exclusive
269	14	3	indifferent
135	6	4	indifferent
37	2	5	constant
5	0.2	6	»
0	0	7	»

Most of the life forms of plants are represented in the flora of Egypt. Many have a very low percentage, few are not represented at all. Therophytes comprise about 50 % of the Egyptian flora, Mega, Meso and Microphanerophytes are not represented, while Nanophanerophytes comprise about 5-6 %. The rest of the species are either Chamaephytes, Hemicryptophytes Geophytes or Hydrophytes.

It is interesting to make a comparative study to the main environmental factors prevailing in these phytogeographical regions with special reference to the climatic and edaphic factors. Autecological and Synecological studies were carried out in different localities distributed in the different regions during the last 20 years. Special studies were carried out in some localities as lake Edko, Lake Manzala, Mariut, Wadi Hof, Wadi Angabia, Wadi Digla, Ghardaqa, Wadi Natrun and many other vallies both in Arabian and Lybian deserts. Autecological studies were carried out on *Zilla spinosa, Zygophyllum simplex, Fagonia arabica, Zygophyllum album, Heliotropeum luteum, Alhagi maurarum* and other common desert plants. Factors affecting root growth of some other plants as *Zygophyllum coccineum* and *Citrullus Colocynthis Farsetia aegyptiaca* were also studied. Special care was given to soil density, penetrability, aeration, water table and other factors affecting development and distribution of plants.

Rate of transpiration and stomatal frequency were also studied in some desert plants.

The climatic factors taken into consideration are :

1. Air temperature.	5. Evaporation.
2. Rainfall.	6. Dew.
3. Relative humidity.	7. Soil temperature.
4. Wind velocity, dust and sand storms.	8. Light.

Soil characters taken into consideration are :

1. Mechanical analysis.	5. Water-soluble salts.
2. Soil moisture, available, non-available and water-holding capacity.	6. Nitrate content.
3. Carbonate content.	7. pH.
4. Humus content.	

Conditions studied to relate habitat factors to the growth and distribution of the plants are :

1. Effect of soil factors on the growth of the plants.
2. Osmotic pressure of the plant sap.
3. Effect of the depth of sowing on the germination of the seeds.
4. Seasonal variation in germination.
5. Penetrability of the soil and root development.
6. Effect of soil factors on root development.
7. Effect of soil factors on ash content and dry weight of the plant and relation of tops to roots.

II. CLIMATIC FACTORS

If we compare the climatological normals in the different localities belonging to different phytogeographic regions of Egypt, we can get an idea about the effect of these factors on the distribution of plants in these regions.

The climatic normals of certain localities belonging to the different

phytogeographical regions are presented for comparison [1]. Arish and Sallum are taken to represent Mediterranean region, Suez, Hurgada and Qosier are taken to represent the Red Sea region. Desert region represented by Heliopolis and Helwan, Nile region represented by Fayoum, Tanta and Asiut. Siwa and Dakhla represent Oases. Nakhl represents Sinai, it would have been represented also by localities on the mountains. Gebel Elba is not recorded in this comparison.

1. *Air Temperature*

Air temperature differs considerably in the different phytogeographical regions of Egypt. In the Mediterranean region it varies between 11.4 and 26.4°C. in the different seasons of the year. In the Red Sea region it varies between 13.9 and 30.6. In the desert region it varies between 13.5 and 30.0. The highest maximum recorded in recent years was 45.8°C. in May 1942 and 44°C. in May 1944. While the lowest minimum recorded recently was 2.8°C. in Jan. 1942. In winter, the air temperature rises to a maximum value of 25 and 30°C. at 2 p. m. and falls to a minimum of 3-10°C at 4-6 a.m. In summer the maximum air temperature is 35°.—40°C or 45°C. at 2-3 p. m., while the minimum of 15°-20°C. is usually recorded at 4-6 a.m.

Air temperature differs greatly in the Nile region according to the position of the locality, Tanta represents Lower Egypt, Asiut represents upper Egypt and Fayoum is considered to be an isolated locality belonging to the Nile Valley. In Fayoum it varies between 11.4 and 28.1, in Tanta it varies between 11.8 and 26.6, in Asiut between 11.6 and 29.4° C. In Oases region, it was found to vary between 10.4 and 38.9 in Siwa and between 12.7 and 30.9° C. in Dakhla. In Sinai, as represented by Nakhl the air temperature varies between 8.7 and 25.4° C. (Table 3).

2. *Relative humidity*

The relative humidity plays an important role in the growth of plants, it has its direct effect on the rate of transpiration in plants. It varies

[1] Climatological Normals for Egypt and the Sudan, Cyperus and Palestine; 1938 : Physical Department, Cairo.

markedly in the different seasons of the year and also in the different hours of the day. It differs greatly in the different phytogeographical regions of Egypt and even in the different localities of the same region.

The Mediterranean region is considered to be humid. In Arish, the relative humidity varies between 71 and 79 %, August and December are the most humid, March and April are the least humid months. In Sallum, the relative humidity varies between 61 and 78, October is the most humid month and June is the least. The annual means are 76 % for Arish and 72 for Sallum.

TABLE (3)

Air Temperature

Phyt. reg.	M		R			D		N			O		S
Locality	Arish	Sallum	Suez	Hurgada	Qosier	Heliop.	Helwan	Fayoum	Tanta	Asiut	Siwa	Dakhla	Nakhl
Jan.	11.4	13.9	13.9	15.9	17.8	13.5	12.2	11.4	11.8	11.6	10.4	12.7	8.7
Feb.	12.3	14.1	14.6	15.8	18.2	14.6	13.3	12.5	11.9	13.2	12.2	14.1	10.3
Mar.	14.7	16.4	17.1	18.8	21.3	17.6	16.5	16.1	15.1	17.2	15.8	18.4	13.6
Apr.	17.4	19.6	20.4	22.1	23.5	21.1	20.3	20.3	18.6	22.2	19.9	23.8	17.6
May	20.6	22.5	24.3	26.1	26.4	24.8	24.0	25.0	23.0	26.4	25.2	27.9	21.8
June	23.0	24.6	26.9	28.7	29.4	27.6	26.7	27.5	25.7	29.0	28.4	30.9	23.4
July	24.8	26.4	28.3	29.5	30.0	28.6	27.5	28.1	26.6	29.4	28.9	30.8	24.7
Aug.	25.6	26.2	28.4	30.0	30.5	28.4	27.3	27.9	26.6	29.1	28.3	30.6	25.4
Sep.	24.4	25.2	26.4	28.0	28.8	26.0	25.3	25.8	24.8	26.4	26.0	28.4	23.5
Oct.	22.2	22.9	23.8	25.0	26.7	23.6	23.1	22.7	22.0	23.6	21.7	24.9	20.8
Nov.	17.1	19.8	20.2	21.4	23.7	19.8	19.0	18.7	18.5	18.5	17.2	19.4	14.8
Dec.	13.0	15.6	14.7	17.7	19.5	15.2	14.1	13.6	13.8	13.6	12.5	14.1	9.6
Mean	18.9	20.6	21.7	23.2	24.6	21.7	20.8	20.8	19.9	21.7	20.5	23.0	17.8

The Red Sea region is less humid than the Mediterranean. In Suez the relative humidity varies between 62 and 70, with a maximum in winter and autumn months and a minimum in spring and summer; Hurgada is relatively drier, the relative humidity varies between 45 and 59; Qosier is still drier, and relative humidity is more uniform varying

between 46 and 55. The annual means are 66, 52 and 51 in Suez, Hurgada and Qosier respectively. The desert region is also relatively dry with a relative humidity of 41-63 in Helwan with an annual mean of 54, 53-75 in Heliopolis, with an annual mean of 66.

Records of monthly means of R. H. were obtained in different localities studied in the desert region. Mean maximum values were recorded in some years in December as 66 %, while the mean minimum was recorded in June as 36 %. In 1946, the maximum values were recorded in January as 62 %, while the minimum was recorded in May as 46 %. The maximum relative humidity of 90-100 % is usually recorded at dawn or before sunrise while the minimum values are usually at 1-2 p. m.

The relative humidity in the Nile region differs in Delta, Fayoum and Upper Egypt. In Delta as represented by Tanta, R. H. varies between 59 and 82 with a maximum of 82 in January, a minimum of 59 in May and June and an annual mean of 72 %, Fayoum is drier, the relative humidity varies between 43 and 74, the minimum represented in May and the maximum in January and December, the annual mean is 60 %. In Upper Egypt, the climate is much drier, relative humidity varies between 37 % in May and June and 70 % in January and the annual mean is 54 %. In Siwa the relative humidity varies between 46 % in May and June 70 in January and December, the annual mean is 58 %. Dakhla oases proved to be the driest locality among all. The relative humidity varies between 28 in June and 49 % in December and an annual mean of 37 % (Table 4).

3. *Rainfall*

Rain in Egypt is a winter one, and the amount of annual rainfall differs considerably in the different phytogeographical regions. The Mediterranean region is the most rainy part of the country. June-September, inclusive, are rainless. In Arish the annual rainfall is 93 mm/anum with a maximum of 16-20 mm. in January, February and December. This amount drops to 8-13 mm. in March, April and November and only 2 mm. in October and May. In Sallum, the

TABLE (4)

Relative Humidity

Phyt. reg.	M		R			D		N			O		S
Locality	Ari-sh	Sal-lum	Suez	Hurg 8 h	Qos-ier	Hel-iop.	Hel-wan	Fay-oum	Tan-ta	Asi-ut	Siwa	Dak-hla	Nak-hl
Month													
Jan.	76	77	70	59	53	75	63	74	82	70	70	48	—
Feb.	76	75	66	54	49	70	56	64	75	62	60	42	—
Mar.	71	69	65	50	50	66	52	60	74	53	57	38	—
Apr.	72	65	63	47	46	58	45	49	66	42	52	34	—
May	73	68	62	45	49	53	41	43	59	37	46	31	—
June	78	61	63	48	48	53	44	46	59	37	46	28	—
July	78	66	64	53	49	59	50	51	68	41	50	28	—
Aug.	79	75	66	51	50	65	54	57	72	46	56	30	—
Sep.	77	77	68	53	51	71	58	63	74	56	57	36	—
Oct.	75	78	70	54	53	74	59	66	77	62	65	38	—
Nov.	75	75	70	52	54	74	61	72	81	67	64	44	—
Dec.	79	76	69	56	55	75	63	74	80	69	70	49	—
Mean	76	72	66	52	51	66	54	60	72	54	58	37	—

annual rainfall rises to 132 mm. with a maximum of 21-38 mm. in January, February, November and December. Several millimetres of rain may fall in March, April, May, September or October. Red Sea region is less rainy, the annual rainfall in Suez is 18 mm., in Hurgada and Qosier rain is very scanty.

In the desert region, the annual rainfall varies between 16 and 31 mm. in the localities chosen for comparison. It is only a few millimetres which fall in winter and autumn months. In the rest of the year rainfall is recorded as traces or none at all. In some years the amount of rainfall may reach 42 mm. In 1944, out of the 42.6 mm. fell in that year, 24.3 mm. fell during the 30th of December of that year and out of the 28.3 mm. of rain fell during 1945, 17.1 mm. fell during the 14th of May of that year. This shows how irregular rain is distributed in this country. The rainy days are very few, they may be 4 or 5 days throughout the whole year.

Early showers of October and November are very important for the formation of new sprouts and germination of seeds. In the deep narrow valleys rain water accumulated at the base of the plateau and acts for sometime as a reservoir supplying plants with water. Silt washed down from the tops of hills or mountains will act as nursary for growing seedlings (Table 5).

4. *Wind, dust and Sand Storms*

Records of wind velocity are not complete, nevertheless the available records show that the wind velocity varies between 10-20 kilometers/hour (Table 6). Sand storms are common in the deserts, they raise clouds of dust and uproot plants and transfer dust from place to place. It causes excessive transpiration, and moves mobile sand dunes. Small annual plants suffer badly from heavy storms, in some cases plants are totally burried by sand.

TABLE (5)

Rainfall

Phyt. reg.	M		R			D		N			O		S
Locality	Ari-sh	Sal-lum	Suez	Hurg 8 h	Qos-ier	Hel-iop.	Hel-wan	Fay-qum	Tan-ta	Asi-ut	Siwa	Dak-hla	Nak-hl
Month													
Jan.	19	38	2	0	0	4	8	2	10	0	2	0	7
Feb.	20	21	2	0	0	3	4	2	10	1	0	0	7
Mar.	13	5	4	0	0	3	5	1	2	0	1	0	4
Apr.	8	0	1	0	0	1	4	1	6	0	1	0	4
May	2	7	1	0	0	1	1	0	3	0	0	0	1
June	0	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0
Sept.	0	1	0	0	0	0	0	0	0	0	0	0	0
Oct.	2	4	0	0	0	0	1	0	0	0	0	0	0
Nov.	13	29	4	0	0	2	3	1	5	3	1	0	0
Dec.	16	27	3	0	0	2	5	5	6	1	3	0	3
Total	93	132	18	0	0	16	31	12	42	5	8	0	26

TABLE (6)

Wind Velovity

Phyt. reg.	M		R			D		N			O		S
Locality	Ari-sh	Sal-lum	Suez	Hurg 8 h	Qos-ier	Hel-iop.	Hel-wan	Fay-oum	Tan-ta	Asi-ut	Siwa	Dak-hla	Nak-hl
Month													
Jan.	14.8	16.4	9.2	16.5	16.1	7.7	13.1	6.1	4.9	6.5	4	3.5	—
Feb.	15.9	17.9	10.1	18.6	16.1	9.3	14.6	6.9	5.7	6.5	5	3.5	—
Mar.	15.2	17.9	12.9	18.0	17.0	9.9	17.1	8.5	5.5	6.5	4	3.2	—
Apr.	14.8	18.7	13.0	18.5	17.0	10.3	18.9	9.3	5.9	6.5	4	4.0	—
May	13.4	16.4	13.1	18.2	16.5	10.6	19.0	10.0	5.4	7.0	4	3.8	—
June	14.9	19.5	16.2	20.1	16.5	10.7	20.5	10.9	5.6	7.0	4	3.5	—
July	15.8	23.5	15.8	20.4	16.1	10.3	18.4	9.8	5.4	7.0	4.5	3.5	—
Aug.	14.7	21.2	15.8	20.2	16.5	10.0	18.3	9.4	4.0	6.5	3.5	3.8	—
Sept.	12.9	18.3	14.5	21.5	16.1	9.5	19.4	10.4	2.9	6.5	3.5	3.5	—
Oct.	10.9	13.9	10.1	16.5	15.8	8.7	18.8	9.6	2.3	6.5	3.5	3.5	—
Nov.	11.6	14.1	9.8	16.5	16.0	8.1	15.7	7.7	3.0	6.5	4.0	4.0	—
Dec.	12.3	16.1	9.2	18.2	16.1	7.4	12.9	5.4	4.2	6.5	4.0	3.2	—
Mean	13.9	17.8	13.5	18.5	16.3	9.4	17.3	8.7	4.6	6.7	4.0	3.7	—

5. *Evaporation*

The evaporating power of the atmosphere varies considerably during the different months of the year in the different phytogeographical regions of Egypt. In the Mediterranean region it varies between 3.65 and 6.21 mm/day at Arish (annual mean 5.26) with a maximum in June and July and a minimum in January and December. In Sallum the evaporating power of the atmosphere varies between 5.96 in January and 11.7 in June (annual mean 8.06). In the Red Sea region the climate is relatively drier. In Suez the evaporating power of the atmosphere varies between 5.01 in January and 13.42 in June with an annual mean of 8.06 mm/day. In Hurgada, the evaporating power of the atmosphere varies between 10.39 mm. in December and 21.11 mm/day in June, with an annual mean of 15.17. In Qosier, the evaporating power of

the atmosphere varies between 6.85 mm/day in December and 11.50 in June with an annual mean of 8.76 mm/day. In the desert region it varies between 3.47 in December and 11.13 in June and in Helwan between 4.87 in January and 16.94 in June with an annual mean of 7.01 in Heliopolis and 10.92 in Helwan. The annual mean of evaporation in the Delta are 5.09 mm. and in Fayoum 7.59 mm. and 8.83 mm. in Asiut. In Siwa the evaporating power of the atmosphere varies between 3.93 in January and 14.86 in June with an annual mean of 9.26. In Dakhla, the evaporating power varies between 5.14 in December and 15.32 in June with an annual mean of 10.57 mm/day (Table 7).

6. *Dew*

Dew is considered by some authorities to be a source of water for some desert plants. It is deposited in all seasons of the year though the amount varies considerably according to the climatic conditions. We have no actual records of the amount of dew deposited. It was determined indirectly as an increase in the water content of the soil at a depth of 0-5 cm. Relative humidity and soil temperature were recorded at the time of sampling. In some cases the relative humidity reaches a maximum of 100 % at 6 a. m. at which time dew is deposited on the soil surface, it drops to a minimum of 39.1 at 1 p. m. Annuals and shallow rooted plants may make use of moisture precipitated as dew under these conditions, seeds may be able to germinate and seedlings flourish. It was found that the soil moisture began to rise at 3-4 p. m. and reaches a maximum at 6 a. m. because of the deposition of dew. At lower depths of the soil the effect of dew becomes rather negligible.

7. *Soil temperature*

Soil temperature affects the rate of absorption, germination of seeds, activity of soil micro-organisms and root development. Soil temperature was recorded in different localities supporting different desert plants using soil thermometers dipped at the required depth of 10, 20, 30, 40 and 50 cm. It was found that the daily temperature range at 1 cm. below soil surface is great and this range diminishes to 20-30 % of its value at 10 cm. and to 4 % of its value at 30 cm. deep. Surface

and air temperatures are much affected by sun rays than the soil temperature at lower levels. Soil surface temperature rises to a maximum at 1-3 p. m. Many desert plants proved to be tolerant to such changes in soil and air temperature.

Table (7)

Evaporation

Phyt. reg.	M		R			D			N		O		S
Locality	Arish	Sallum	Suez	Hurg 8 h	Qosier	Hel-iop.	Hel-wan	Fay-oum	Tanta	Asiut	Siwa	Dakhla	Nakhl
Month													
Jan.	3.65	5.96	5.01	11.81	7.04	3.65	4.87	3.03	2.34	3.62	3.93	5.21	—
Feb.	4.73	7.31	5.77	11.77	7.35	4.77	6.74	4.46	3.20	4.97	6.07	6.40	—
Mar.	5.56	7.92	7.39	13.58	8.09	6.22	9.26	6.08	4.32	7.33	7.41	9.03	—
Apr.	5.58	8.96	10.18	15.69	9.03	8.62	13.02	8.71	6.07	10.69	9.04	11.57	—
May	5.81	8.19	12.17	17.63	9.57	10.02	15.21	11.62	7.61	13.07	11.94	13.96	—
June	6.21	11.7	13.42	21.11	11.50	11.13	16.94	13.42	8.47	15.45	14.86	15.32	—
July	6.13	11.0	12.96	18.97	10.15	9.95	15.61	11.97	7.43	13.16	14.33	15.13	—
Aug.	5.71	8.7	12.50	19.08	10.28	8.72	14.69	10.24	6.35	12.58	13.40	14.40	—
Sept.	5.86	7.3	10.69	17.66	9.83	7.20	12.24	7.70	5.34	9.85	11.30	13.05	—
Oct.	5.47	6.8	8.61	13.83	7.87	6.01	10.14	6.40	4.30	6.77	8.61	10.33	—
Nov.	4.60	6.9	6.61	11.48	7.53	4.47	7.27	4.48	3.24	4.47	5.62	7.31	—
Dec.	3.82	6.06	5.20	10.39	6.85	3.47	5.17	3.13	2.46	3.45	4.59	5.14	—
Mean	5.26	8.06	9.21	15.17	8.76	7.01	10.92	7.59	5.09	8.83	9.26	10.57	—

8. *Light* :

In desert region plants grow where illumination is usually at its full strength. Cloudy days are very few even in the coastal localities of the Mediterranean region. Some plants may be seen growing at the base of high cliffs in the shade of others. Desert plants growing in the shade attain larger diameter and height, larger leaves and internodes. All dimensions taken for shade plants were larger than those taken for sun plants. Shade plants growing in the desert are protected against excessive transpiration and disturbance of water balance.

III. EDAPHIC FACTORS

1. *Mechanical analysis* :

Soil samples were analysed mechanically using the pipette method to give an exact idea concerning the structure of the soil.

Coarse and fine sand form most of the constituents of the soil in the desert regions. Silt and clay are rather inconspicuous. It is only in few cases when samples are taken from beds of valleys after a heavy rain which washes down fine silt from tops of plateaus that the percentage of silt and clay rises. In almost all cases coarse and fine sand form about 90-95% of the soil in the desert (Table 8). This structure has its effect on the water content of the soil, salinity content, humus content as well as nitrate content. Water percolates easily between the coarse soil particles. A great proportion of water evaporates readily at ordinary temperature. Water-soluble salts leach easily. The water holding capacity is also affected. This structure has its effect on the root development, penetrability and branching. Easy percolation of water makes ground water not within the reach of the roots, they penetrate deeply

Table (8)

Mechanical Analysis of the Soil

No.	Locality	Depth	Coarse sand	Fine sand	Silt	Clay
1	Angabia	0-5	49.93	39.91	3.5	1.7
2	»	15-20	61.33	29.85	1.4	3.18
3	»	25-30	59.50	36.03	1.1	1.0
4	Suez Road	0-5	27.85	59.40	4.1	3.15
5	» »	15-20	29.45	57.74	4.3	3.62
6	Slope	0-5	39.62	48.66	0.5	6.0
7	»	15-20	27.94	57.72	0.1	8.02
8	Heliop.	0-5	24.28	64.17	3.08	1.9
9	»	15-20	32.99	63.17	2.45	1.1
10	»	25-30	49.46	43.74	1.48	1.35

searching for it. In some cases, roots spread very near to the soil surface in order to be able to secure any precipitated moisture on the soil surface or in the upper layers of the soil.

Soil structure in other phytogeographical regions differs greatly with an increase of the clay and silt contents specially in the Nile region and in clayey shores or islands in some lakes where clay rises to 40-50 % and silt to 20-30 %, fine sand 15-20 % and coarse sand 5-10 %.

2. *Moisture Content*

It is true as Fitting (1911) mentioned, that xerophytes must have strong physiological adaptations that enable them to withdraw their required water from the scanty amount that may be found in the soil or precipitated in any form on its surface or in between its particles in its upper layers. The total water content in the different localities studied in the desert region varies between less than 1 % and 6 or 8 %. Most of the water is evaporated at ordinary temperature and only a small amount is left for the high temperature of the oven to expel. In Wadi Hof, the southern slopes differ from the northern ones in the fact that the water content in the former is $^1/_3$ rd that of the latter, that is due to a longer exposure to sun rays. It was found that the water content of the soil differs in the different localities in the different seasons of the year and in the different hours of the day.

To find out the effect of soil moisture content on the morphological characters of some xerophytic plants, dimensions of stems and leaves of plants growing in different localities were determined. Results revealed the marked influence of soil moisture on the morphological characters of the plants. Plants growing in localities with higher water content, have long stems, long internodes and long leaves. Soil moisture affects also the flowering season of the plant.

In the Mediterranean region, the water content is relatively higher than in the desert one. In the sandy districts it varies between 9 and 15 %. In low depressed areas it reaches 20-30 %. The amount of water left for the high temperature of the oven to expell is relatively higher than in the desert soils. The water content of the soil is subject to seasonal fluctuations. It is also much affected by the humus content.

Gradual decrease of water content of soil is more or less regular as we leave the shores or in islands in the lakes. This gradual decrease or increase of the water content is generally accompanied with a change of the plant communities. Some plants are more tolerant to dryness than others.

In salt marshes near the Red Sea shores the water content is relatively low except in depressed parts.

In Sinai the water content was found to vary between 1 and 7 or 8 %. It is more or less similar to that of desert with a relative higher percentage.

The water holding capacity is the real measure of the nature of the soil. It shows a great variation in the different phytogeographical regions of Egypt. In the desert region it varies between 20 and 25 %, in some cases it falls to 16 %. High percentages of 35 % were found in protected parts of Wadi Hof, Wadi Digla or Wadi Rashrash due to a higher percentage of silt in the soil.

The water holding capacity of soils in the Mediterranean region shows a higher value. It varies between 30 and 35 %. Soils of the Red Sea region have similar values of water holding capacity. In Sinai, the water-holding capacity was found to range between 20 and 25 %, a range which is more or less similar to that of the desert.

3. *Humus Content*

Humus is known to increase the water holding capacity of the soil. It is stated that the water content is a function of the humus content.

In the desert region the humus content was determined in many localities supporting desert plants as *Zilla spinosa, Alhagi maurorum, Peganum Harmala, Citrallus Colocynthis* and many others using the rapid titration method. The amount of humus content varies between 0.1 and 3.6 %. Humus is very low in Gebel Asfar, Suez road, Almaza and others, where in most soils it is less than 1 %, in very few cases it rises to 2 or 2.5 %. In Wadi Hof, Wadi Digla and Wadi Rashrash humus content is relatively higher, in many samples it is more than 1 %. In Sinai, the humus content is relatively higher than in the desert region. This may be attributed to the topographic conditions and to the

richness of the vegetation. In the Mediterranean and Red Sea regions, the humus content is relatively high and samples with 2 or 3 % humus content are more or less common.

As to the amount of humus at the different depths of the soil, no general rule could be drawn out, though there is a general tendency to increase with increase of depth. In some cases an increase in the amount of humus is followed with a decrease. Such variations which were specially detected in profiles of 150 cm. deep may be due to local activity of microrganisms or activity of roots at the different depths. It was noticed also that samples taken in spring and autumn months got higher percentages of humus than those taken in summer.

In cases we get sandy and clayey spots in the same locality or sandy and clayey islands in the same lake, the humus content is lower in the sandy than in the clayey ones. The low water content of the sandy localities may be attributed, at least in part, to the low humus content, the water retaining capacity of humus is known to be high. The humus content of the soil is greatly affected by the density and nature of the plants growing in the soils. Humus content determined as loss on ignition is found to be much higher than that determined using titration method. Such determinations were not taken into consideration in this comparative study.

In shores of lakes or seas a definite gradation in the amount of humus is sometimes observed but the type and density of vegetation are not to be neglected. In Mariut of the Mediterranean region, dune area has humus content less than the rocky ridge and the bed of the lake got the highest percentage of humus content.

4. *Water-soluble salts*

The amount of water soluble salts in the desert region is very low, it is in most cases less than 0.5 %. It was only in samples near by salt marshes where it exceeds 1 % where *Zilla spinosa* or *Zygophyllum simplex* were growing. This shows that such plants are not tolerant to any salt accumulation. Except in very few cases, the amount of soluble salts is less at the lower depths than at the upper ones. This is due to the dryness of the desert, the salts being brought up to the upper

layers. Water content being greater at the lower depths will cause the dilution of the salts at these depths. In Helwan there were two areas near by each other, one supporting *Zygophyllum simplex* associated with *Zygophyllum coccineum* and *Z. album,* while in the other only *Zygophyllum album* exists. The marked variation between the two areas lies in the amount of water soluble salts being 1 % in the former and 6 % in the latter.

Z. simplex and similar annual shallow rooted desert plants cannot tolerate such high degree of salinity in the superficial layers of the soil and they fail to grow. In yellow hills such plants fail to grow in saline soil, while near by they were successfully growing where there was no accumulation of salts. The total amount of water soluble salts is relatively higher in Gebel Asfar, it varies between 0.5 and 0.7 %. In few associations it rises to 1.3 or 1.5 % and in few others it was less than 0.2 %. In the rest of the localities studied in the desert, the amount of water soluble salts varies between 0.1 and 0.2 %. In few cases it proves to be higher or lower than that range.

In Sinai, the range of water soluble salts varies between 0.1 and 0.4 %. Where the salt content rises to a much higher percentage, we notice that the community changes from the xerophytic to the salt marsh one.

In the Mediterranean region where the salt marshes and lakes are common, the water soluble salts increase to a considerable extent. In several islands and lakes and sea shores, we find that the amount of water-soluble salts increases as we leave the shore. It sometimes begins with 1-2 % near the shore and increases gradually where there is a wild halophytic vegetation of *Atriplex portulacoides, Salicorinia fruticosa, Inula crithmoides, Arthrocnemum glaucum,* then to a higher extent where there is *Halocnemon strobiliaceum* and *Cressa cretica* and then to a still higher extent where the soil becomes absolutely bare of vegetation. *Cressa* and *Halocnemon* proved to be more tolerant to salt accumulation than other halophytes. Similar gradation was recorded in many sea shores and islands in the Egyptian lakes. Of these salts, the chlorides form a great proportion, while free alkali salts are less richly represented.

The rest of the water soluble salts proved to be soluble nitrates, phosphates and soluble salts of organic acids.

In the Red sea region the range of water soluble salts is not so high. In some localities near the sea shore or in some islands scattered in the sea where *Atriplex, Arthrocnemum, Halocnemon* and *Zygophyllum album* are growing, salinity varies between 1 and 4 %.

In Melaha valley where *Juncus, Tamarix, Suaeda* and other plants are growing, the percentage of water-soluble salts is not considered to be of high value in such a salt marsh. The highest percentage was recorded where *Juncus* consociation is flourishing. In the remaining spots it varies between 1 and 6 % and is invariably less at the lower depths. In higher and drier parts of the valley, the vegetation is that of a desert though low depressions support halphytic plants.

An interesting gradation in the amount of water soluble salts is marked in the Mediterranean region at Bourg el Arab. In the dune region which is the nearest to the Sea and the soil is sandy, salinity varies between 0.2 and 0.5 %. In the rocky ridge it varies between 0.3 and 0.6 %. In slopes facing the bed of the lake where vegetation is mixed and the halophytic plants are flourishing, it rises to 1-1.5 %. In the bed of the lake, it rises to 2-6 % where the community is a pure salt marsh one.

Wadi Natrun is a very wide valley in the Libyan desert about 80 km. to the N.-W. of Cairo. It is very rich in different salts as Na_2CO_3, Nacl and Na_2SO_4. The salty parts hardly support any plant, higher and drier parts support common desert plants as *Pithyranthus tortusus, Panicum turgidum, Zilla spinosa, Hyoscyamus muticus, Artemisia herba alba* and many others. Low depressed parts support *Typha latifolia, Juncus acutus, Cyperus* sp. and *Suaeda* sp. The amount of water soluble salts varies between 0.59 and 2.1 % which is considered to be relatively low when compared with other saline regions.

In Abu Minkar island in the Red Sea, soil is clayey and is flooded with sea water. It supports a dense vegetation of *Avicennia officinalis*. The percentage of water soluble salts is considered to be high except where *Zygophyllum coccineum* grows where it is 1 %. In the rest of samples salinity was found to be relatively high and chlorides form a high proportion of these salts.

5. *Carbonate content*

Calcium carbonate is known to have a neutralising effect on the soil acids, diminishing the toxicity of certain salts, flocculating clay fraction of the soil, cementing the sandy particles thus improving the texture of the soil.

The range of carbonate content in desert soils supporting *Zilla spinosa* in different localities is very wide. It differs in different sopts of the same locality and at different depths in the same spot. For *Zilla spinosa* it was found to varry between 0.1 and 25 %, for *Zygophyllum simplex*, it varies between 0.13 and 42.29 %.

Carbonate content is considered to be very low in Suez Road, Almaza, Wadi Melaha, Wadi Saki and Gebel Asfar. Near the Pyramids of Giza, it varies between 0.1 and 3 or 5 %. In Wadi Digla, W. Hof, W. Rashrash, on the other hand, the percentage of carbonate content is relatively very high, where it varies between 8, 10 to 25 or 40 %. Soil is calcareous and rain washes down the limestone from the plateaus on either side to the bed of the valley.

In Sinai, the carbonate content was found to vary between 1 and 6 %, in few cases it was less than 1 % and in few others it rises to 12 %; both extremes were recorded in St. Katharine mountains.

Some plants are indifferent to $CaCO_3$, while others are more or less carbonate indicators, both belong to the genus *Zygophyllum*. *Zygophyllum simplex* proved to be a dominant plant in Abu Zaabal, Wadi Hof, though the CO_3 content is very low in the former being 0.43 % while in the latter the soil is calcareous with a CO_3 content of 30-40 %. *Zygophyllum coccineum*, on the other hand, is a carbonate indicator. In Suez Road, the plant is almost absent in the first 50 km. where the CO_3 content is very low, then it appears in the next 10 or 20 km. where CO_3 content is high.

At about 100 km. distant from Cairo the plant appears again forming an almost pure consociation, where the soil was found to be calcareous with a high percentage of carbonates.

The plant is common in W. Hof, W. Digla where soil is calcareous

and almost absent in Yellow Hills and the first 50 km. of Suez Road, Almaza and many other localities where CO_3 content is almost negligible. Wherever the plant is found, the soil on which it grows was found to contain a high percentage of $CaCO_3$. The CO_3 content was found to exhibit no effect on the growth of *Z. simplex,* but *Z. coccineum.* Carbonate content has its effect on the plant which was not found growing successfully on soils with little carbonate content.

In Mediterranean coastal region, CO_3 content varies considerably. In Lake Manzala, CO_3 content varies between 2 and 10 % in clayey islands, while in sandy islands, it rises to 60 or 70 %. In the latter case mollusce shells are present in enormous quantities. In Dergham near Damietta, CO_3 content is very low, about 1 %.

In Mariut, CO_3 content varies in the different localities, in the dune region it varies between 20-30 %, in the rocky ridges 12-18 %, in the bed of the lake 7-10 %.

In the Red Sea region CO_3 content varies between 1 and 10 or 12 %. In Abu Minkar it is relatively low where *Avicennia* grows and relatively higher when *Halocnemon* grows.

In Melaha valley the soil is calcareous, soils supporting *Z. coccineum* and *Pulicaria,* CO_3 content reaches 30 %. It is relatively low in localities supporting *Tamarix, Juncus, Suaede* where it falls to 2 or 4 %.

6. *Nitrate Content :*

The nitrate content was determined colourimetrically using diphenylamine as an indicator. The NO_3 content proved to be very low in the localities studied supporting such plants as *Zilla spinosa.* Nitrates are known to leach easily from the cultivated soils, they are expected to be more leachy from the sandy soil of the desert. Soils supporting *Z. simplex* and *Alhagi maurorum* contain appreciable amounts of NO_3, a case which is not common in such a sandy soil of the desert. This is most probably due to the presence of root nodules with their N_2 fixing bacteria on the roots of *Z. simplex* and *Alhagi maurorum.* Soils supporting *Zilla* proved to be poor in nitrates except where a Leguminous or *Zygophyllaceae* plant is an associate.

7. *PH.*

The soil reaction in the different phytogeographical regions of Egypt proved to be alkaline. The range of pH is very wide, it lies between 7.2 and 9.1.

In Wadi Hof	7.2-8.8
Yellow Hills	7.4-8.0
Suez Road	7.3-8.2
Sinai	8.4-9.1

As to the reaction of soil solution at different depths, it was found that the solution is generally slightly less alkaline at the lower levels. This is attributed to the evaporating power of the atmosphere which brings salts upwards. This is a different condition from that found in rainy countries, where rain washes down salts, pH is acidic and acidity increases with depth. Humic acids have their effect on the soil reaction. High alkalinity is generally accompanied by high CO_3 content, high water soluble salts and by lower humus content.

In Mediterranean region the soil reaction is distinctly alkaline both in Lake Manzala and Mariut region.

It is to be mentioned that different factors interact, so that we cannot determine exactly which has the profound effect on the pH. Moreover the effect of some factors may be marked by some others.

IV. SUMMARY.

1. Egypt is divided into seven phytogeographical regions, supporting more than 1800 species.

2. Most of the life forms of plants are presented in the flora of Egypt. Many have a low percentage and few are not represented at all. Therophytes comprise about 50 % of the Egyptian flora, Mega, Meso and Microphancrophytes are not represented, while Nanophanerophytes comprise about 5 %. The rest of the species are either Chamaephytes, Hemicryptophytes, Geophytes or Hydrophytes.

3. A comparative study of the climatic and edaphic factors prevailing in the phytogeographical regions of Egypt was carried out. Results presented in this study were obtained from autecological and synecological studies carried out in Egypt in the last twenty years.

4. Air temperature differs considerably in the different phytogeographical regions of Egypt. It varies between 11.4 and 26.4 C in the Mediterranean region, 13.9 and 30.6 in the Red Sea region, 13.6 and 30.0 in the Desert region. Highest maximum of 45.8 and lowest minimum of 2.8° C were recorded. In summer, the maximum air temperature varies between 35°-40° C at 2-3 p. m., while the minimum of 15-20° C is usually recorded at 4-6 a. m. Air temperature differs greatly in the Nile region according to the position of the locality; it varies between 11.4 and 29.4° C. In Oases, it varies between 10.4 and 30.9 and in Sinai between 8.7 and 25.4° C.

5. Mediterranean region is considered to be humid; in Arish, the relative humidity varies between 71 and 79 %, August and December are the most humid, while March & April are the driest. In Sallum, relative humidity varies between 61 & 78, October is the most humid & June is the least. Red Sea region is less humid than the Mediterranean. Relative humidity varies between 62 & 70 in Suez, 45 & 59 in Hurgada and 46 & 55 in Qosier. Desert region is considered to be dry, annual means of relative humidity are 54 in Helwan & 66 in Heliopolis.

Mean maximum values of relative humidity were recorded in some localities in the desert region in December as 66 %, while the mean minimum value was recorded in June as 36 %. The maximum relative humidity of 90-100 % is usually recorded at dawn or before sunrise while the minimum values are usually recorded at 1-2 p. m. Relative humidity in the Nile region differs considerably according to locality, in Delta, the mean being 72 %, in Fayoum 60 % & in upper Egypt 54 %. In Sinai, the annual mean of relative humidity is 58 %. Dakhla oases proved to be the driest of all, the annual mean of relative humidity being 37 %.

6. The Mediterranean coastal region is the most rainy part of the country. June-September inclusive are almost rainless. Annual rainfull is 93 mm. in Arish, 132 mm. in Sallum. Red Sea region is much less rainy, the annual rainfall is 18 mm. in Suez, in Hurgada & Qosier rain is very scanty. In the Desert region the annual rainfall varies between 16 & 31 mm. in the localities chosen for comparison. Rain is very irregularly distributed in the country. Out of the 24.6 mm. fell in 1944, 24.3 mm. fell during the 30th of December of that year. Out of the 28.3 mm. fell in 1945, 17.1 mm. fell during the 14th of May. Total annual rainfall is 12 mm. in Fayoum, 42 mm. in Delta & 5 mm. in Asiut of the Nile region. Total annual rainfall is 8 mm. in Siwa, 0 in Dakhla & 26 mm. in Sinai.

7. Wind velocity varies between 10 & 20 km./hour. Sand storms are common in the deserts causing excessive transpiration & moving mobile sand dunes. Small annual plants suffer badly from heavy storms.

8. Annual means of evaporation are 5.26 in Arish & 8.06 in Sallum of the Mediterranean region. Red Sea region is relatively drier. Annual means of evaporation are 9.21 mm./day in Suez, 15.17 mm. in Hurgada & 8.76 mm. is Qosier. Evaporation in the other phytogeographic regions varies between 7.01 & 10.57 mm/day.

9. Dew is deposited in all seasons of the year, the amount varies considerably according to the climatic conditions. Annuals & shallow rooted plants my make use of moisture deposited as dew under these conditions, seeds may be able to germinate & seedlings flourish. It was found that soil moisture began to rise at 3-4 p. m. reaching maximum at 6 a. m. because of deposited dew.

10. Soil temperature affects rate of absorption, germination of seeds, activity of soil microrganisms & root development. Daily temperature range at 1 cm. below soil surface is great, this range diminishes to 20-30 % of its value at 10 cm. & to 4 % of its value at 30 cm. deep. Soil surface temperature rises to a maximum at 1-3 p. m.

11. Cloudy days are very few even in the coastal localities of the Mediterranean region. Shade plants which may grow in the desert attain larger diameter & height, larger leaves & larger internodes.

12. Coarse & fine sand form most of the constituents of the soil in the desert region, silt & clay are rather inconspicuous. This structure has its effect on the water content of the soil, salinity content, humus content as well as nitrate content. It has also its effect on the root development, penetrability and branching.

Soil structure in other phytogeographic regions differs greatly with an increase of the clay & silt contents specially in the Nile region & in clayey shores or islands in some lakes where clay rises to 40-50 % & silt to 20-30 %, fine sand 15-20 % & coarse sand falls to 5-10 %.

13. Total water content of soil in the different localities studied in the desert region varies between 1 & 8 %. Most of the water is evaporated at ordinary temperature and only a small amount is left for the high temperature of the oven to expel. Soil moisture affects both the morphological structure & the flowering season of the plant. In the Mediterranean region, the water content is relatively higher than in the desert. In sandy localities it may rise to 15 or 30 %. Gradual increase or decrease of water content from shores inland or in islands in the lakes is generally accompanied with change of plant communities or associations. Water content in Red Sea region is relatively low except in depressed parts. In Sinai, the water content is more or less similar to that of the desert with a relatively higher percentage in some localities.

14. The water-holding capacity of the soil in the desert region & Sinai varies between 10 & 25 %. Higher percentage of 35 % which was found in protected areas in Wadi Hof, Wadi Digla & Wadi Rashrash is attributed to a higher percentage of silt in the soil. In the Mediterranean and Red Sea regions, the water-holding capacity of the soil varies between 30 & 35 %.

15. Humus content varies between 0.1 & 3.6 % in the different localities studied. Humus is very low in Suez Road, Gebel Asfar, Almaza & others where it is less than 1 %. It is relatively higher in Wadi Hof, Wadi Digla & Wadi Rashrash. In Sinai it is relatively higher than in the desert region. In Mediterranean & Red Sea region it is again relatively high & samples with 2 or 3 % humus content are more or less

common. Humus content of the soil is greatly affected by the density & nature of the plants growing. It is generally lower in sandy than in clayey soils.

16. Amount of water-soluble salts is very low in the desert region, it rarely exceeds 0.5 %, usually varies between 0.1 & 0.2 %. Many desert plants cannot tolerate high degree of salinity. In Sinai, the range of water soluble salts varies between 0.1 & 0.4 %. Where the salt content rises to a much higher percentage, the community changes from xerophytic to salt marsh one. In the Mediterranean and Red Sea regions, the amount of water-soluble salts is much higher than in the Desert or Sinai & halophytic plants flourish. *Cressa cretica* & *Halocnemon* proved to be much more tolerant to salt accumulation than other holophytes. Chlorides form a great proportion of the water soluble salts, free alkalies are less richly represented; the rest proved to be soluble nitrates, phosphates & soluble salts of organic acids.

17. The range of carbonate content in desert soils supporting *Zilla spinosa, Zygophyllum coccineum* . . . etc. is very wide. For. *Zilla spinosa* it varies between 0.1 & 25 % & for *Z. simplex* it varies between 0.13 & 42.29 %.

Carbonate content was found to be very low in Suez Road, Almaza Wadi Melaha, Wadi Saki & Gebel Asfar (0.1-5 %). In Wadi Digla, Wadi Hof & W. Rashrash, on the other hand, it varie between 10-40 %.

In Sinai, the carbonate content varies between 1 & 6 %. Some plants are indifferent to $CaCO_3$ as *Z. simplex,* while others are carbonate indicators as *Z. coccineum.* In Mediterranean coastal region, carbonate content varies considerably; in clayey islands of lakes it varies between 1 & 10 %, while in sandy islands it rises to 60 or 70 %. In the sand dune strip at Mariut, carbonate content varies between 20 & 30 %.

In the Red Sea region carbonate content varies between 1 & 10 or 12 %.

18. Nitrate content proved to be very low in the different localities studied in the phytogeographic regions of Egypt. Soils supporting *Zygophyllum simplex* & *Alhagi maurorum* contain appreciable amounts of nitrates, probably due to the presence of root nodules.

10.

19. Soil reaction in the different localities studied proved to be alkaline. The range of pH varies between 7.2 & 9.1 Soil reaction is generally slightly less alkaline at the lower depths. This is attributed to the evaporating power of the atmosphere which brings salts upwards. This is different from that found in rainy countries when rain washes down salts & acidity increases with depth.

20. The wide range of pH and other soil conditions under which plants can live is striking. That is the case, not only for indifferent species which grow in any region, but also for the same species growing in different localities in the same region.

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PROTECTION OF FLORA AND CONSERVATION OF NATURE IN EGYPT

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CONTENTS

I. INTRODUCTION

For a country as Egypt, it is of utmost importance to protect flora and conserve nature. More than 96 % of its area is a sandy rainless desert and only about 3 % of its area is a cultivated land. Cultivation is totally dependent upon the waters of the River Nile.

Egypt is divided into seven phytogeographical regions, each is characterised by certain habitat factors and supports a characteristic flora of its own. These regions are : Desert D, Mediterranean coastal region M, Red Sea coastal region R, Nile N, Sinai S, Oases O, and Gebel Elba.

Egypt supports more than 1800 species of plants which are distributed in these different phytogeographical regions. About 750 species

* UNESCO — Symposium, Beirut, June 1954.

or 42 % of the Egyptian flora are annuals which appear only in the very short rainy season and then disappear. Trees are very poorly represented in the flora of Egypt, Mega, Meso and Microphanerophytes are absolutely absent and only few Nanophanerophytes or small trees flourish in certain parts of the country, these comprise about 5 % of the flora. Other life forms of plants, namely Chamaephytes, Hemicryptophytes, Geophytes and Hydrophytes are fairly represented in the Egyptian flora.

The Mediterranean coastal region is the richest of all, it supports about 900 species or 50 % of the flora; of these 300 are indigenous to this region. The desert region supports 757 species of which 125 are indigenous. Sinai supports 527 species of which 134 are indigenous. The Nile region supports 543 species of which 126 are indigenous. Gebel Elba is a region of relatively high mountains (1450 m.). Its flora differs greatly from that of the other regions. It supports 231 species of which 121 are indigenous. In the Oases, there grows 335 species of which 26 are indigenous. The Red Sea region is considered to be the poorest of all. It supports 31 species of which 11 are indigenous.

About 400 species or 20 % of the Egyptian flora are considered to be indifferent *i. e.* found in any region but not characteristic to it. Fourty two species or 2.2 % of the flora are considered to be constant *i. e.* found in five or more of the phytogeographic regions. There are about 50 % of the Egyptian flora which are absolutely exclusive *i. e.* confined to one region only (Hassib 1951).

In the desert region, as well as in many localities of Sinai, plants grow in valleys and depressions where rain water accumulates and washes down silt which acts as nursaries for the seedlings of the desert plants. Of these valleys we may mention Rashrash, Hof, Angabia, Digla, Saki, Qena, Arak and many others in the Arabian desert and Wadi Natrun in the Libyan desert; Tala Tih, Arbin and others in Sinai.

Destructive agencies of vegetation are quite numerous and variable. Beduins, grazing animals, fires, floods, man activities in cultivation, construction of dams and reservoirs, drains, pumping stations which are constructed in the North of the Delta and other projects of irrigation, drainage or increasing cultivated areas are destructive to the flora of the country.

II. DESTRUCTIVE BIOTIC FACTORS

(Beduins & Grazing animals)

Wadi Rashrash about 35 km. to the East of Saaf is to be taken as an example of the effect of protection of flora. The Wadi was owned to ex-king Farouk and was absolutely protected against destructive agencies. The plant associations were flourishing in an exceedingly marvellous condition; vegetation was rich and luxurient. *Zilla-Alhagi, Fagonia-Farsetia, Zygophyllum-Paronychia* and many other associations were stretching over wide areas. The degree of cover was astonishing in such a desert dry region.

Vegetation in other valleys as Hof, Angabia, Digla .... etc. is subject to the destructive action of Beduins with their grazing animals, and their activity in collecting dry plants for fuel. School boys are in some cases very severely destructive, setting fires to fry sweet potatos. Plants are sparsely scattered, vegetation is open and poor.

In Sinai peninsula, *Tamarix* forests were common, now they are destructed and abandoned as a result of the activity of the Beduins and their grazing animals.

In the Red Sea coastal region, *Avicennia* forests were flourishing on the coasts of the sea and its islands. It has almost disappeared and is almost confined to one island which is Abu Minkar. That is attributed again to the effect of the Beduins and their grazing animals.

It is to be mentioned also that many of the plants which are grazed by animals are declining and gradually disappearing from their native homes in the desert where they had for a long time eceised e. g. *Nitraria retusa, Capparis spinosa, Alhagi maurorum* and *Ephedra alata*. Other plants which are not palatable as for example *Zygophyllum coccineum* is very little affected.

Salvadora persica was formerly flourishing in Wadi Qena and Wadi Arak, it has been very badly affected through the activity of Beduins and grazing animals. *Salvadora* is now imported to Egypt.

One of the most important medicinal plants will soon disappear from

the desert due to the activity of Beduins in collecting and selling it. This is *Hyoscyamus muticus* from which Hyoscyamim is prepared. The cultivated *Hyoscyamus* never gives the same active principal as that found in the wild plant. Egyptian *Hyoscyamus muticus* is known all over the world for its medicinal value. Had it been cut above the soil surface, it would have continued growing instead of being destructed through uprooting.

Balanites aegyptiaca is another plant which has almost disappeared through the activity of Beduins and their grazing animals. *Balanites* is now almost restricted to the Oases.

It is well known that Mariut district near Alexandria is very rich of beautiful flowers which are cut by the Beduins and sold very cheaply in Alexandria or to those driving over there. Such plants are very seriously damaged and unless the season is rainy they hardly come up.

Between Alameen and Sallum is a region which was ten years ago the stage of terrible battles of last war. Rich plant associations are now flourishing in the protected mine fields. It is an example of the effect of protecting flora and conservation of nature in this district. Where neither Beduins nor grazing animals can carry on their harmful effects to vegetation, plants do come up, by and by become enriched and cumulative fertility is at its best.

III. IRRIGATION AND DRAINAGE SYSTEMS AND PROJECTS AS DESTRUCTIVE AGENCIES

As a result of the development of irrigation systems and constructions of dams and barrages, digging deep drains, and building pumping stations have their destructive effect on the growth and distribution of numerous plants.

In the Nile region, some plants have totally disappeared as a result of the development of summer irrigation instead of the basin one. *Pistia stratiotis,* the floating hydrophyte, has totally disapeared from the Nile region except at the very North of the Delta and in the Sud region of the Sudan. The same with *Cyperus Papyrus* which exists now only in the Sud region and was formerly growing in Egypt.

There are many other plants which were formerly flourishing in the Nile waters or any of its tributaries, canals or drains have totally disappeared. Of these the water Pteridophyte or Hydropteridae *Azolla* is to be mentioned. *Azolla* has almost disappeared while *Marselia* being rooted in mud is still flourishing in our canals and drains.

It is very probable that many of our ancient Egyptian plants which were flourishing in Egypt in past times have totally disappeared as a result of such destructive agencies.

Many of the *Acacia* and *Ziziphus* trees which were once flourishing behind the Aswan dam have now totally disappeared. Aswan dam and similar dams or barrages which are every now and then constructed or elevated are destructive for many trees which may be growing in their vicinity, being flooded with water throughout the year or at least for several months every year and thus the habitat is totally modified specially the water content of the soil. *Glycyrhiza* and *Prosopis* are to be mentioned in this connection. They are very badly effected through change of habitat, they could be grown again if we can keep up their original habitat.

IV. COMBINED EFFEC OF BIOTIC AND CLIMATIC FACTORS ON PLANT SUCCESSION

It is well known that plant succession takes a definite route according to the prevailing habitat conditions. A plant sere on rock differs from that in a pond, and that on sand is totally different from that on river banks.

A xerosere passes through the following stages until it reaches the climax which the habitat conditions and especially the climate can afford. It begins with a crustose lichen, followed by a foliose or fruticose one, then herbs followed by shrubs and lastly by the climatic climax. Each stage is preparing conditions for the next and making them impossible for itself. Soil becomes finer, humidity and humus increase gradually.

A Hydrosere takes another route, beginning with submerged plants

followed by floating ones, the formers entangle soil particles while the latter diminish light and the habitat is gradually prepared for the reed vegetation which fix banks and raise soil and the habitat is prepared for the herbaceous vegetation followed by shrubs and the climatic climax.

A psammosere or succession on sand is much affected with the mobile sand dunes which are in turn much affected with the activity of man in trying to stop them or else they threaten villages and fields. Man is trying to stop the movement of the dunes by cultivating wind breaks in the proper direction and also by cultivating suitable plants in the proper time to fix the dunes.

Succession on river banks and islands is much affected through the activity of man in constructing dams, barrages and bridges.

It is obvious that the stages of every sere are very strongly affected by the combined effect of the activity of man in cultivation, irrigation, drainage, fires, lumbering and grazing of sheep and goats.

Such agencies and factors do not only affect such flowering plants but also affect the microflora, algae, fungi and lichens which grow and flourish both in soil and in water.

At least for indigenous and exclusive species we should be very careful, keep botanical records for every region or locality and take strict measures to protect our flora.

Scientists and specially Biologists should draw the attention of governments to the importance of protection of flora and conservation of nature.

V. HOW TO PROTECT FLORA AND CONSERVE NATURE

1. A list of flora should be immediately prepared. The flouristic composition of every region of the phytogeographic ones of the country is to be made. The occurrence, degree of cover and distribution of every species is to be studied and recorded. Ecological studies regarding the presence, abundance and frequency of every species are to be carried out. Autecological studies of the common species and synecological studies of representative localities are to be carried out by specialists *i. e.* an ecological survey of the country is to be carried out.

2. We have to publish such studies in a special journal which may be called «Egyptian Biological Flora». Such studies require a team organised work, carried out by young Botanists and supervised by the leading ones. Unesco commitee of Arid Zones and Desert Institutes have to participate in organising and helping both financially and scientifically in issuing such journal.

3. In every phytogeographic region of the country, we have to create a national park or garden in which all plants growing in the region are cultivated, propagated and kept under conditions more or less similar to the natural ones where they grow. Glass houses, canals, caves, rocky places and sandy ones are to be created for the purpose.

4. In every region we have to study the possibility of creating together with the Botanic garden an institute in which researches of problems of protection of flora and conservation of nature are to be carried out. In such institute, practical suggestions for the implementation of an effective protection of nature will come out.

5. Small representative areas in each of the different phytogeographic regions are to be selected, these areas should be preserved against the different destructive agencies. Such preservation should be enforced by legislations and laws.

6. Ecologists should be consulted before beginning any cultivation, irrigation or drainage projects.

7. Some of our sandy shores are subject to erosion as that near Burollos or Ras-el-Bar on the Mediterranean coast. It is stated that 50 years ago the Sea shore was about 1 km. distant from the village (Borollos) and is now only few meters far. Such shores should be strengthened by building terraces. By this means, we are not only protecting the dune plants and the land supporting them but we are also protecting the inhabitants against this continuous threaten of the Sea and the dunes.

8. It is very essential to educate the public the importance of protecting flora and conserving nature. We have to bring this importance

to the attention of the governments, scientists and informed public opinion and to create the love of nature in children, school boys and laymen.

9. We have to make use of the press, radio, cinema and schools. Articles written by specialists are to be published for the purpose. Books treating such subjects are to be published. Programmes of education both in primary and secondary schools should take part in this respect.

10. Excursions to the country side, deserts, mountains, lakes, islands, shores, sea-sides ... etc. are to be arranged every now and then. Scientists take the lead in such excursions to draw the attention to the importance of conservation of nature and protection of flora. At the same time they show people how to make useful collections without spoiling, destructing or doing any damage to plants.

Such generation educated in this manner and participating in such activities will protect the flora and conserve nature in his country.

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LINEAR STRUCTURES IN AND AROUND THE NILE BASIN

(COMPARATIVE ANALYSIS OF TECTONIC EVOLUTION IN NORTH AFRICA)

(with 4 maps, 3 diagrams and 4 photos)

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CONTENTS

DEFINITION, PROBLEM, AND INTRODUCTION

TERMINOLOGY. — *Structures* are architectonical features of the earth's crust. They concern the mutual relation and distribution of rock units : firstly as structurally controlled product of either endogen (igneous or metamorphic in the widest sense of the word) or exogen (external) evolutions, and secondly in their arrangement after they have reacted upon a mechanical disturbance of their equilibrium by distortion or fracture.

Linear structures are surface-intersections of two-dimensional structural features showing an oriented arrangement which allows—theoretically—to determine their mechanical meaning.

The Nile Basin comprises Egypt and the Sudan ; «*around*» *the Nile Basin* means in a wider sense the greater structural frame, that is the neighbouring regions of *Africa, Arabia* and the *Indian Ocean*.

Two problems are the back-ground of this paper.

1st. The development of a master stream of the size of the Nile [1] through the ages within its «greater» structural frame. Furthermore the question, if the present structural appearance or «phenotype» is older or younger than the River itself, or if the mechanical frame-development by great-scale-warping persists and still influences the course of the stream.

2nd. The question, whether or not structural features of only slightly deformed geological units, for example, basins of the size of the Paris-Basin, filled by alternating layers of limestones and marls (but with prevailing competent beds and resting on a mechanically heterogeneous layer of Nubian sandstone, which itself covers basement formations) can be traced by means of a secondary and mainly external development as drainage lines are. That means, whether erosional features may serve as indication of minor structures.

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[1] 6.700 kms. long with a water amount of 600 m^3/sec. in may-june and 8.000 m^3/sec. at its highest in september near Wadi Halfa.

Furthermore : whether such minor structures are generally of little importance for a greater structural analysis, or do indicate definite mechanical evolutions more or less uniformly governing a composite sequence of sediments.

Both questions are intimately connected not only with each other, but with the whole evolution of a junction of two continents, and also with the present shape of the most conservative portion of the earth, Africa as a whole, and with the face of Egypt and the Sudan.

We know from elsewhere, that geomorphological developments are unquestionably governed by structural phenomena (Fjord formation, structural scarps, etc.), but we do not know the extent of this dependency.

The authors met with the questions when the major and minor structural elements of Egypt were about to be collected. It was found that very few details were available of structures within the Western and Eastern Desert of Egypt as far as the «limestone plateaus» are concerned. Still their existence had to be anticipated. There were exceptions to this lack of information in areas offering some interest from the economic point of view. Aerial photographs, which were met with incidentally, convinced us that actually the wadis, at least in the Western Desert (calcareous portions), could supply good information or at least indications of the structural pattern. Even in the nearly featureless Western Desert some drainage lines, especially in the Nile-near reaches (besides the arrangement of escarpments, of basalt occurrences etc.) were rather interesting from the structural point of view.

It is a commonplace that erosion follows lines of less or least resistance. It has been shown in a recent detailed work on the structural features of the Pyramids area near Cairo (Omara, 1953) that direction diagrams (rose-diagrams) of drainage lines within that particular area did coincide remarkably well with the diagrams directly derived from the analysis of minor structures in the rock-exposures proper.

Exceptions were expected and are to be shown : 1) in the areas which are covered by broad gravel-sheets of Oligo-Mio-Pliocene age ; 2) in the sand-covered areas especially west of the Nile, obliterating «pre-dune» lines and inhibiting the creation of new-ones ; 3) perhaps within the

peculiar and genetically as yet unsolved areas of Oasis-depressions in the Western Desert with their special and localised base-level. These depressions were found (Hume, 1906) to be somehow related to the architectural plan of the country and therefore dealt with in a special chapter (p. 195).

In the following pages we shall discuss the problem : A) from the major; B) from the minor structural point of view; C) the method applied shall be reviewed; D) we shall discuss special problem connected with our aim, as desert depression formation etc. [1].

I. THE NILE BASIN

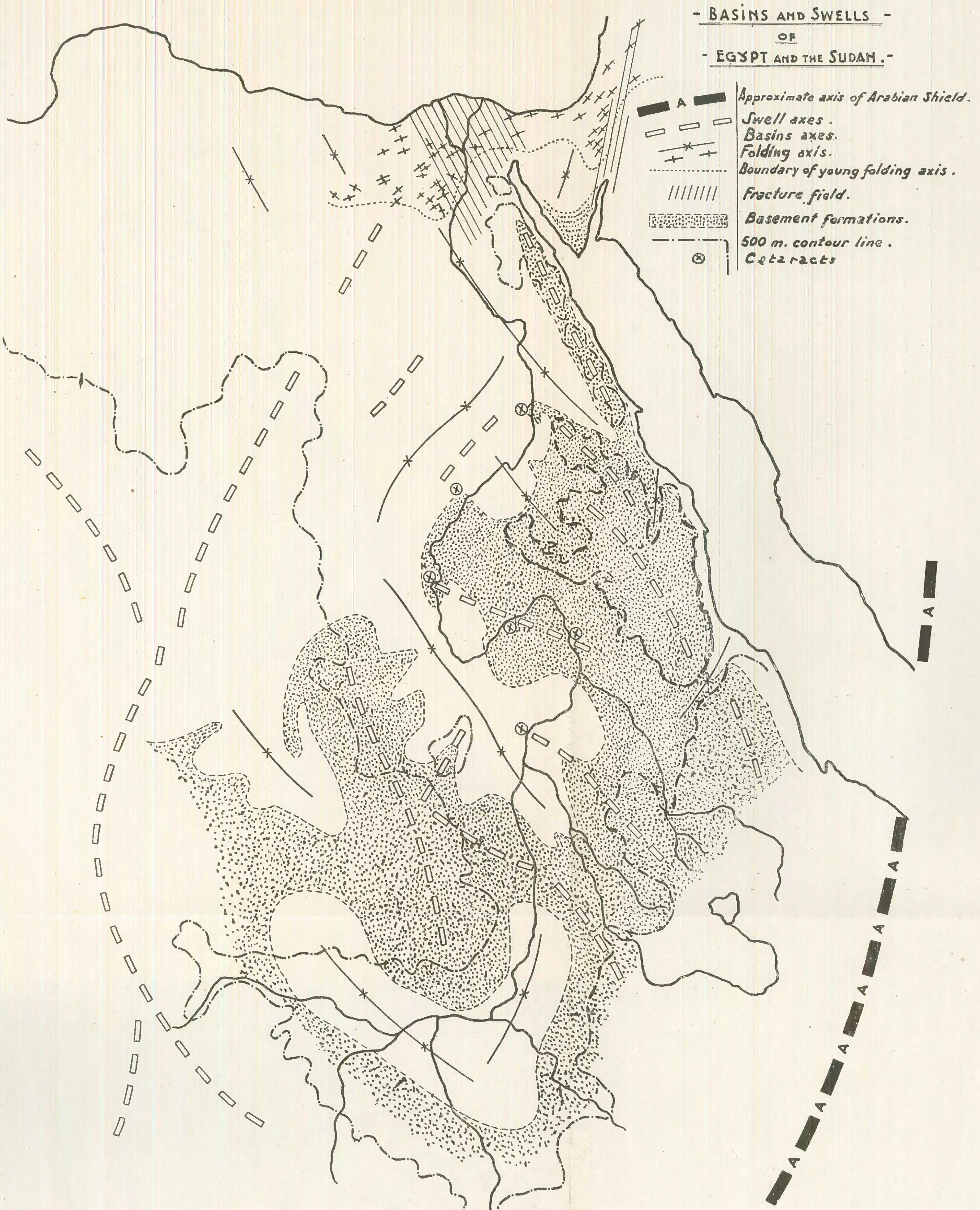
A. Swells and Basins Generally

Map n° 2 gives morphological or rather orographic outlines of the Nile Basin, while map n° 1 indicates the distribution of the basement-outcrops within the area.

So n° 2 map allows a comparison with chiefly morphological features elsewhere, while n° 1 map gives rise to the question if this morphology is mainly due to the action of external dynamics (erosion, etc.), or to internal forces and developments (warping, etc.). We suspect the latter and assume as working hypothesis that most of the basement outcrops along the Nile or a cataract-portion of the river indicates à lifting tendency of the country.

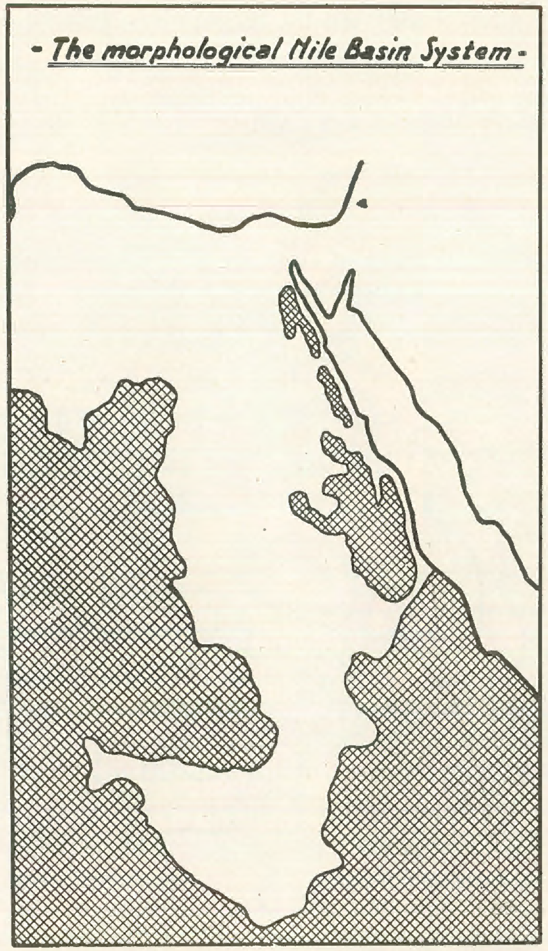
This question, whether external or internal forces are stronger in the shaping of the « face» in a slow, old and conservative continent is of high importance since—as we shall see—similar great outlines are displayed on the floors of some oceans. We do not know as yet whether we shall or can attribute a part of their shaping to external, subaerial processes of former times. We do not know yet, whether we may abolish the « law

[1] As far as the authors understand, Prof. Dr. M. Pfannenstiel of Freiburg/Germany is either publishing or has just published a paper on the Origin of the Egyptian Oasis depressions. Since the authors could so-far not get any closer informations concerning this paper, they were not able to refer to it in their work.


- BASINS AND SWELLS -
OF
- EGYPT AND THE SUDAN. -
A
Approximate axis of Arabian Shield.
Swell axes.
Basins axes.
Folding axis.
Boundary of young folding axis.
Fracture field.
Basement formations.
500 m. contour line.
Cataracts
A

Map n° 1.

of permanent oceans and continents» in favour of a high vertical mobility of « l'écorce terrestre ». Some light may be thrown on this great problem by the analysis tried in the following pages. It concerns the great sym-



Map n° 2.

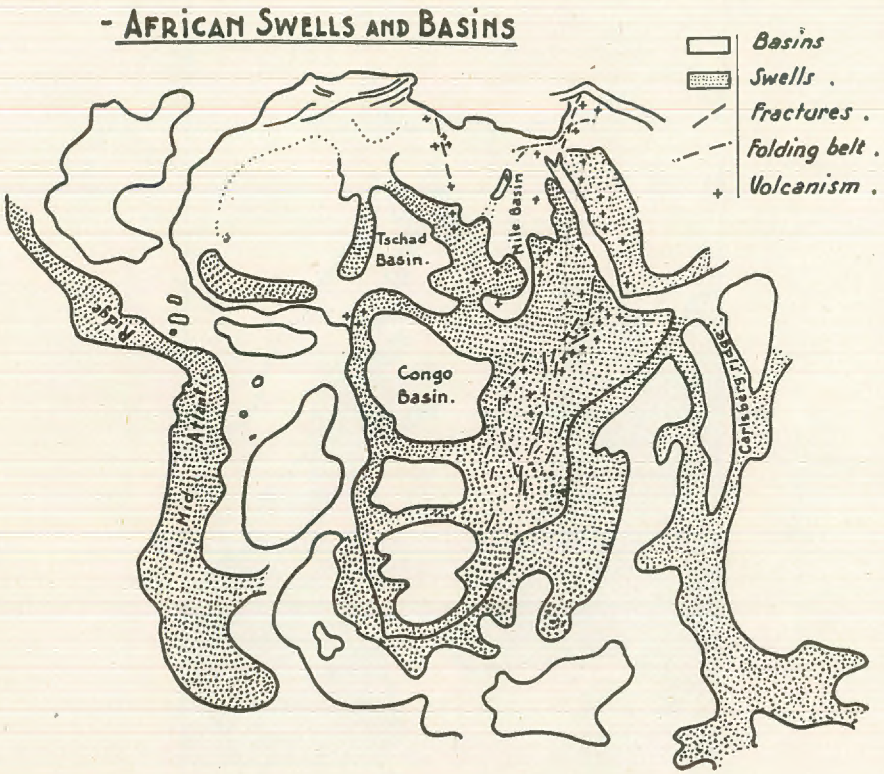
phony played by a thousand geological and meteorological instruments since the origin of the earth.

Map n° 2 therefore shows the « sounding» features of a continental basin, while n° 1 tries to give a « geological snapshot» of a deeper and

still lasting evolution which directly displays the problem of structure and morphology on a great scale and a high order of space and time.

Both maps cover practically the whole area drained by the Nile from the Southern Sudan to the Mediterranean Coast.

Map n° 3 displays a still greater frame, since this alternating arran-



Map n° 3.

gement of smaller (possibly « secondary ») depressions constituting the greater Nile basin shows, as indicated already, close similarity to the other basins of the African Continent and within its Oceanic surroundings. This map will give a chance for a comparison. It has been drawn following H. Cloos (1937) and Umbgrove (1947) rather than Hume (1943) whose map is too generalized.

A few words on African swells and basins, serving as « containers » of huge drainage systems.

We know the Orange River draining the Karroo-Basin in South Africa. This great river comes from a humid hinterland and crosses finally extreme deserts (Knetsch, 1940), after flowing through semi-arid reaches.

The Congo is a similar feature modified only by the fact that is flows during its whole course under the influence of a humid climate.

The Niger shows an analogous position and, we know (Knetsch, 1950) that, in a comparatively recent past, when we had a higher rainfall figure in North-Africa, similar, although smaller drainage systems have been developed in some of the smaller (« secondary ») basins within the central and northern Libyan Sahara (Tripolitania).

These varied and colourful analogies give a hint towards common and analogous causes. Such logical, geological backgrounds seem to be at least of a continental size and order.

We shall try to find steps leading towards a solution of such causes in the Nile basin itself or in a comparison of the Nile basin with analogous features elsewhere.

Huge but shallow depressions of the type and the size of « high-African » basins seem to represent, together with their separating swells (Bucher, 1939; Cloos, 1937; Hume, 1948 and others), a type-feature of « stable » of « inert » (Stille, 1943) areas of the globe. They are common in the shield or cratonic (Stille, 1943) areas which appear to behave more rigidly in the course of structural development in post-palaeozoic times than the areas distorted by post-palaeozoic differential orogenetic or epirogenetic developments. We know also, that the shield areas did only behave in a more rigid manner although they are not more rigid than other portions of the sialic portions of the globe, since we must assume that the forces distorting « l'écorce terrestre » mechanically don't mind a few 1000 m. more or less of basement formations.

We can therefore anticipate that these smooth structural features commonly referred to as swells and basins (Cloos, 1937, Bucher, 1939) are the expression not of a particular rigidity of the earth crust in these portions of the globe, but of a particular attitude of the « substratum »-portions (or what-ever initiates the greater tectonic evolution

and shaping of the earth's outer shell). It seems remarkable that we find the swell-and-basin-arrangement not only in « high-cratons », that is continents, but in « low » or « deep » cratons (some oceans) also.

Besides, while some of the swells and basins have apparently been formed in early times of the history of the earth, others, and especially our particular Sudan-Egypt-features may have been created in comparatively recent times. In this connection the remark of Sandford (1943) concerning the possibly pre-jurassic age of the West-Libyan Edeyen or « Erg » basins is worth mentioning. If that is so, we must conclude that the swell and basin-formation (or accentuation) is not a testimony of a special development as polygonal pattern (Cloos, 1937) of the earliest history of our earth, but a « mechanical working pattern » (as ripple-marks are, or geosynclines), an expression of—possibly subcrustal—developments acting through the ages and—in all probability—represented by another style of tectonics (orogeneous and, or germanotype tectonics etc.) in other portions of a different architecture of the globe. If we are not mistaken, the optimum for the acute fracturing developments of the greatest scale, at least as far as more or less vertical movements are concerned and the greatest-scale-volcanism (which actually displays a vertical development too), seems to be confined to swell regions. This concerns swells on high cratons (Stille, 1935) as well as in deep cratonic areas where we cannot observe directly clear fracture zones of the type in question but analogous volcanic evolution (Mid Atlantic ridge or swell).

Such features will have to be inspected within our comparatively small region and the limited scope of this paper. The area however, comprises swells, basins, rift-valleys, volcanism as well as the transitional steps into « weaker zones », as shelf areas are and the mechanical « halo » of alpidic disturbances represented by the folding belt of the Syrian arc or arcs (Krenkel, 1941) in Lower Egypt.

Since, for several reasons, the areas in question could not be investigated personally and intimately, we had to confine our interpretation to maps and literature. Photographs, ideas and proposals, working theories and hypotheses of former authors have been considered although not always referred to in detail.

We shall—this result may be mentioned before-hand—see that the huge basin-system of the upper and middle Nile, which in its size is directly comparable to the Angola and Karro basins further south (Cloos, 1937) and even exceed in area the Tschad basin, is—at least as far as its subdivisions are concerned—younger than its southern analogies. Since its shows a subdivision in a number of smaller units, which are not represented in the southern analogies, we shall have to deal with this special feature separately. So this subdivision is natural and not done for working reasons. We shall name such smaller units « basins and swells of second order », indicating a natural mechanical subdivision of the greater areas into smaller units in more recent times. That means a relief pronouncing internal development. Since, as mentioned, a similar « dissolution » into sub-units so-far is not reported from the high cratonic regions in Central and South Africa, we assume that it might be an indication of the neighbourhood of the geosyncline, at least parageosyncline (Stille, 1943) or a labile shelf portion (v. Bubnoff, 1949) in the North. It might be the mechanical « halo » of the northern orogenesis.

B. The Nile Basin in particular and its frame

The huge swell bordering the Sudan towards the East belongs to the East African « back bone », one of the most essential positive morphological and geological features of the Earth.

It displays « basement formations, which are only to a small extent covered by sedimentary blankets. The basement is exposed from far south, actually from northern Transvaal and Southern Rhodesia through the whole eastern portion of the African Continent and includes the south-western part of the Saudi Arabian Peninsula.

On the whole, this basement backbone shows a sigmoidal curvature and represents a mirror image picture of the Mid-Atlantic ridge in the West (compare Stille, 1937). It is although wider than the Atlantic ridge. It is furthermore similar to the nearby (smaller) Carlsberg ridge (Umbgrove, 1948) in the Indian oceanic field. It actually joins with the last named element at the Southern margin of the Saudi Arabian Peninsula (See map n° 3).

The East-African-Arabian swell displays along the southern two-thirds of its length the huge Graben Systems of East Africa together with a volcanism which increases to the North. This increase in volcanism takes place simultaneously with the diminishing size of the Rift zone proper and nearly ceases where the Rift attains its biggest size in the Red Sea Graben area. Here, the fractures follow a new (probably global) law, the Red Sea Rift turns out of the swell axis and strikes due NW. (perhaps in the «Narben» zone of an old orogen (Krans, 1951) The accompanying volcanism practically disappears, or rather it migrates from the Graben portions proper to the adjoining areas where feeder-fissures are more likely to be created (compare Cloos, 1939, Knetsch, 1950) [1].

A Graben by the tight fitting of its sharp boundary faults, blocks the vertical migration-chances of solutions; magma etc.; gaping gash-veins, feather-joints, échelon-fault-systems and like features produced by shear promote such migration. In this respect it is remarkable that the greatest volcanic activity along the Rift-zone is not only where the «mirror-image» Graben-(or keystone-)faulting ceases, but where there is a break in the direction of the Graben. This concerns the Northern extension (Lebanon etc.) of the Graben also and may indicate a certain lateral shifting along the Graben-«rails».

While the great fracturing features run parallel to (but actually hardly touch) our southern basin areas, the volcanism extends in scattered occurrences into the basin complex. Our volcanic witnesses are not only branches of the vast Abyssinian volcanism. They indicate apparently another mechanical system with a definite meaning which is not yet clearly understood.

The bordering frame immediately south of the Nile Basin belongs to the same back-bone system, which splits up into the N.E.-trending main swell (the Nubian Arabian shield of Krenkel, 1925) and a great W to N.W.-striking swell, separating the Nile Basin from the Tschad-Basin and extending towards the Tibesti-Hoggar-warp (Picard, 1943; Knetsch,

[1] Murawski gave (1951) in a different sense and different region a similar explanation in creating the term «hinge volcanism» connected with warps of smaller extent rather than with fracture zones.

1950; Hume, 1948; Andrew, 1948 and others). It releases a few side-branches of a smaller order, framing the middle and lower basins to the West and North West.

The direct North Eastern boundary, namely the system of the Red Sea mountains belongs again to the Nubian Arabian units. Its arrangement «en échelon» may be due to the oblique junction of *a*) the huge marginal fault-zones of the Red-Sea-Graben proper and *b*) the slightly oblique axis-subparallel faults of the Northern Nile Basin (underlined by the arrangement of volcanism between Assyut and the Fayoum etc., see below). On the whole, the basement seems to be subdivided in wedge-shaped, very acute or pointed units reminding us somewhat of the saxonic-hercynian «lower-floor-wedges» (Harz region etc.) of Northern Germany (Knetsch, 1950 *a*).

En échelon-structures of this type as well as «feather-faults» [1] may also be due to a mechanical compromise between Graben-directions and local mechanical anisotropies (deviation of basement-grain from the fracturing-directions, etc.). This arrangement seems to be mainly confined to the region S.E. of the «Akaba-line» and its S.W. projection, that is the N.E.—fracture—component of the Red-Sea-Graben, which intersects the western Red Sea mountains near Qoseir. It produces a very marked basement fracture-system in the Aswan district.

These side swells: Tibesti swell, its smaller N.E. branches (compare the «swell-virgations» of Argand, 1924), in some respect the Red Sea mountains also, on the whole initiate a new element of the African Swell and Basin System. This new, linear character-element is advertised already further S.E. in the arrangement of the western border-basins of the Indian Ocean. While the swells of High-Africa do hardly show a marked orientation and do rather indicate roughly polygonal outlines, which provoked the «unit» theory of Cloos (1937), our particular area shows, as well as the Carlsberg ridge area and its basin systems in the Indian Ocean a typical «D» arrangement or D-orientation (Wüst, 1939; Stille, 1943; Estorff, 1946 and others), and besides a somewhat

[1] The term is derived from «feather joints».

« twisted » and « flowing », sigma-like distortion. This analogy points to an equal geotectonic value of the units just mentioned, especially since they are approximately of the same size. The Nile Basin thus offers an opportunity to investigate a « marine-type-basin » on dry land. Besides, it gives a chance to study the « flow-line » configuration, which is, on the whole, rather exceptional, but seems to be typical for the Africanear portions of the Indian area, or the preserved parts of S-E-Gondwanaland.

The acute D-arrangement is very conspicuous in the Indian Triangles in the Peninsula of Sinai and the Delta of the Nile (Krenkel, 1925; Sonder, 1938; Stille, 1943 and others).

It may also be mentioned in this connection that in our own « D » systems, the N.W.-direction points more towards the W, than the N.E.- « arrow » to the east. This tendency is neatly displayed by the directions of the Gulf of Suez and the Gulf of Akaba in the destructive (Stille, 1944) or fracture portion of our region. In both cases : *a*) the acute fractures and *b*) the smoother swells and basins, we arrive at a definite grid, or lattice, a pattern with the directions named erythreatic and somalic by Krenkel (1925) [1].

But, as mentioned before, most of the D- features described before the writing of this paper, were either fractures or continental margins (Jessen, 1936, Knetsch, 1940). We know that for example younger geosynclines only rarely follow such directions for greater distances. The equally different attitude of the « normal » African swells was mentioned. We therefore take this direction of the Red Sea and its borderlands for normal fracture or flexure-D-patterns, but notice the D- arrangement for the first time in our continental swells.

[1] We must admit, that this pattern (especially its exaggeration by Sonder 1938) did trouble us a bit in the beginning stages of this work. Patterns that are so conspicuous and seemingly simple are mostly somehow deceiving. Besides, nature hardly presents straight lines. Even the Red Sea « meanders » somehow, although Graben-areas are among the very few nearly straight elements of the earth. We found also, that as soon as we modify the straight line system of Krenkel a bit (and we are sure that this is actually in the intention of the author himself) the arrangement looks more natural and less « technical ».

This concerns the Tibesti-swell as a swell of 1st order. Being more or less subparallel to the Red Sea, it does also concern the Baharyia-warp, the cataract swells etc., that is swells of first and second order in size, branch swells, split apart from the huge Arabian and Tibesti swells and loosing themselves somewhere beneath a cover of young and inconspicuous, often nearly featureless sandstone or calcareous formations. We shall see that their continuation beneath such covers may be indicated by other structural elements of the cover formation.

Such indications are found : *a*) in the conspicuous increase in N.-E.- joints in the area directly N.-W. of Quena, *b*) by anticlines, that is proper folding in the N.-E.-projection of the Bahariya-swell. And this would not only prove that their origin is not (or not only) a vertical warping-up but also a laterally acting force.

That would mean furthermore that we can anticipate a similar, possibly « lateral » origin for the basins. On the other hand, this fact, especially displayed by the Baharyia-swell and its N.-E.-projection-folds (Chata, 1953) shows the replacement of one tectonic style by another type of crustal reaction as soon as thê boundary of greater tectonic units are crossed (here the frontier between a more stable unit in the south and a more labile shelf area in the North).

If we understand Bubnoff (1938 and 1949) right, this swell-formation actually falls under the heading of « dictyogenesis ». It is closely related and very similar to the « finger-like protrusions » of « lower-floor-units » into typical shelf—areas of Central—and Northern Germany (Thüringer wald, etc.) as explained by Richter, 1934; Bubnoff, 1938. This concerns especially the Eastern Desert-region.

The features mentioned are drawn on the maps. It might be pointed out that the direction of the « smooth » negative elements of this system, namely the enclosed basins between the swells show the same attitude, a N.-W.-N.-E.-lattice with slight curves, one basin replacing the neighbouring one, in a « skating-step-manner », in a manner which directly indicates a mechanical meaning, a definite reaction of the crust itself, possibly upon a stress clutched by the slow friction below a solid shell, if crustal reactions do play a role worth while speaking of in such—subcrustal current—developments. Do they, we may have thus an indication

that such reactions are somewhat different in the thicker sialic continental portions than in the Indian Ocean and shelf-portions of the Northern African sphere.

Such we see and interprete the greater tectonic frame of the Nile [1].

II. THE DEVELOPMENT OF THE NILE COURSE

A. The Upper Nile (with same remarks on the lower portion)

We shall see from observations further downstream that the actively eroding Nile in its present course might date from shortly pre-middle-Pliocene times only. This concerns the Nile valley approximately from Luxor to the Delta.

The question, how far the Upper Nile drainage reaches back into the past remains still to be considered. It was certainly governed by morphology and precipitation. Morphology is initiated by tectonics which renew relief and inclination but may block existing drainages. Swells and Basins did exist before Miocene (Picard, Cuvillier, Tromp). They partly controlled the location of the River bed. We know that, prior to Pliocene some stream must have come from the south and gone to the wider Mediterranean area but we do not know its course or length although we may anticipate portions of its course further west than the present course of the Nile, at least as far as its lower reaches are concerned.

We know furthermore, that in the time of the origin of the Aswan Iron ore, probably in Lower Cretaceous time some big drainage line must—although probably with a low gradient—have entered the Nubian sandstone shelf sea in the vicinity of Aswan; we have seen, that at the base of the (so far) youngest portion of the Nubian Series, namely uppermost Cretaceous near Aswan, a stream entered the upper cretaceous sea in that area, but we have no exact dates as far as these developments and their time intervals are concerned. We can only assume that the

[1] More recent details about the Sudan-portion are given by Andrew 1948.

Nubian-sandstone region was a shallow nearly relief-less shelf sea probably fed by sand-transporting rivers [1].

Whether the apparent lack of greater relief (for exceptions see Andrew 1937) during that period was primary or produced by the relief-smoothening sediment is not quite clear, but since no pronounced polymict conglomerate-accumulations (with the exception of a comparatively small amount of quartz-pebbles) are reported from the Egyptian Nubian Series, the smooth relief was probably a «peneplain» formed by intensive chemical weathering.

There were shallow indentations in the migrating shelf-sea-shore as indicated by the greater age of the Nubian Series (Andrew, 1937) towards the West (Tibesti) and the East (Sinai and Arabia) [2].

During the Cretaceous and Eocene transgressions the rise of the sea-level might have been uniform, although a slight accentuation of pre-existing positive elements (Eastern Desert?) most probably took place (Attia, 1953). This could point either towards an early evolution towards the fracturing area. It could, if it concerns the other (for instance Baharyia) swells also, indicate an accentuation of the entire relief. Probably it concerned a higher structural tendency governing swell-formation *and* Graben-formation in the sense of producing different effects in different tectonic units, folding in the North, fracturing in the East, warping in the rest-portion of the area.

This synchronization is a hypothetical assumption (compare E. Kraus, 1951).

The present limestone distribution in Egypt gives an idea of the deeper

[1] Wind-delivery, as suggested by Shukri (1944/1945) seems doubtful, since a number of features indicate rather a warm and humid climate in the adjoining hinterland which would prevent dune formation (compare Andrew 1937); Kaolinization, Iron- and silica-migration, the latter persisting according to Sandford from Palaeozoic times until the Tertiary, point in the same direction.

[2] Shukri (1944/1945), Shukri and Said (1944) and Hume (1906) assumed that the base of the Nubian sandstone was a peneplain. They confirm furthermore that hardly any heavy minerals of local origin are contained in the Nubian sandstone, but the heavy mineral content was mainly derived from distant and older sandstone (1944/1945). This speaks for very low and feature-poor relief.

portions of that particular sea only. The limestone areas have—in all probability—been accompanied around the southern and eastern margin of their present-day distribution by a belt of contemporaneous sandy sediments of shelf character, a « nubian facies ». In some places intercalations of the two facies are still preserved (Attia and Murray, 1952). Most of the loose clastic sediments have been eroded in later times, thus creating—besides the usually steep marginal scarp of the limestone plateaus—the conspicuous morphological depression ($\pm$ 200 m. contour lines) between the limestone scarp west of Kalabsha and the present Nile south of Aswan.

Concerning the smaller basins further south, we may for some reasons (Andrew, 1941 and others) anticipate that the basins in question formed local base-level first. What happened to the water draining towards these basins depended on the climate of the region at the time in question, that is on the ratio of the precipitation, runoff (or collection) versus evaporation; but it seems rather safe to assume that for some time these separate basins did not allow the Nile to flow through towards the North (compare Hurst and Phillips, 1938). Andrew although assumes that the drainage of the Blue Nile towards Egypt was never completely interrupted, while the White Nile outflow was for some time locked. He also assumes a continuous deformation of the Sudan area (pp. 119-120). We are not aware whether or not he takes into consideration the drainage of U-cretaceous to Eocene times into the Aswan-area-shelf sea. At present, while apparently the warping development is going on (as shown by the rapid incision of the river through its cataract-portions) the river itself can cope the warping action. And a logical deduction from the time of peneplanation of the Nubian base with the river coming from the south and the apparently consequent basin formation could come to the conclusion that the subdivision of the Sudanese unit in smaller Basins took place after the time-boundary between Cretaceous and Eocene.

Lawson (1927) is of the opinion that the Sudan did not drain into the Nile before Quaternary times. He attributes the rapid incision in its between Khartoum and Aswan to the formation of a new river (Quaternary).

On the other hand Lawson himself speaks of uplifts in the area in question. He also infers an axial direction differing from the assumed axes of this paper (see map n° 1).

The cataract stretches, if taken as « working » uplifts, show—by the way—a remarkable equidistance, somehow comparable to the width of the Red Sea Graben.

To our mind the eroded Nile valley-portion between Luxor and the Delta was created during a rapid probably late miocene or early pliocene accentuation of morphology by tectonic deformations [1] that is the —possibly isostatic—adjustment following the tremendous fracturing between Oligocene and Miocene.

Whether the hinterland of the Nile before this time was confined to Wadi Quena, Wadi Zeidun and possibly the huge dry rivers S.-E. of Kom-Ombo, or there was actually a connection towards the Sudan, we do not know for certain yet. We know however of southern rivers up to the Uppermost Cretaceous south of Aswan. So there is a gap between the Upper-Cretaceous and the Oligocene. Regionally the gap covers the area between the hinterland and the migrating coast line.

Whether a permanent River « followed » that coastline, depends mainly on the climatic conditions of the regression-times.

The river might have been cut off from its older, that is Nubian southern catchment areas (if it had any) in Middle-Pliocene times for a comparatively short period and succeeded in reaching its present extent again in late Pliocene times, just before a rapid acceleration of the

[1] If we compare these events with other North-African developments (omitting on purpose the lengthy and often repeated discussion of controversial ideas between authors connected with Egypt and Palestine only) and refer to Glangeaud (1950), then we see that we have clear paroxysm of lateral compression from Middle-Eocene to Upper-Oligocene times in the Western Mediterranean area, a second-one in Pontian to Quaternary times, both of them with clear tension and local compression producing echelon-folds and monoclines. An overlap of Graben formation (lower Oligocene) and highest compression (mostly normal to its long axis) in Upper Oligocene times seems to be certain.

Glangeaud states that the Pont—to quaternary—movements are entirely different from the previous distortions (conf. Rittman 1952).

warping set in again, which, also, could be compensated by erosion (cataract-portions). This erosion took place between Aswan and Korosko after a definitely humid, probably late-pliocene epoch, as proved by fossil meandering river courses with well-worn pebbles ending at a level of approximately 80 m. above the present stream bed and followed by rapidly incising episodic (that is dry) rivers (Knetsch, 1953). The humid period in question was doubtless considerably pre-palaeolithic and we assume it for some reasons (to be dealt with below) as upper-pliocene.

The present Nile follows more or less the axes of *some* basins or *one* crescent-shaped basin of the Southern Sudan. Further North (N. of Khartoum) it fights its way through the barrages which to our mind prove the undiminished warping development. Probably a considerable diminution of the Nile-water would stop its present erosive power and block its way for some time. Structural deformation (or accentuation of relief by internal dynamics) would then only partly be compensated by external agencies, which try to fill depressions and smoothen heights. We shall observe similar developments, but with slightly different style, in the structural development of Middle and Lower Egypt. Its frame also is a different-one. The difference is due to the comparatively near alpidic development which seems to affect the northern fringe of the continent considerably.

We are fully aware of the fact that this short review could or should be completed with lengthy and detailed references from literature. We also confine ourselves to the short sketch given above, trying to find the main-direction of events.

We therefore come to the end of the chapter on the Upper Nile section of our area with referring again to the maps n^{os} 1, 2, 3. A short resumé may lead over to the North.

Accordingly we follow the River further downstream and towards the North, the Aswan-Luxor-section. Geologically we come from a basement-exposure to the Northern Nubian-Sandstone-region, which is in the Nile section first represented at its southern Egyptian outcrop as a slight N.-E.-trending depression containing the Nubian sandstone. This small basin East of Aswan closes towards Kalabsha and is framed towards

the N.-W. by a slight but conspicuous N.-E. pointing swell with partially exposed basement.

It has been mentioned in some of the works concerned with our area that the exposed portions of the basement within these reaches are pre-Nubian positive elements, namely hilly portions of the pre-Nubian peneplain. This is possible, since the pre-Nubian base is a *pene*-plain, not a plain. Besides, it seems to have been slightly more dissected or irregular towards the present Nile bed south of Aswan even in pre-Nubian times than it is to the West and East of this stretch.

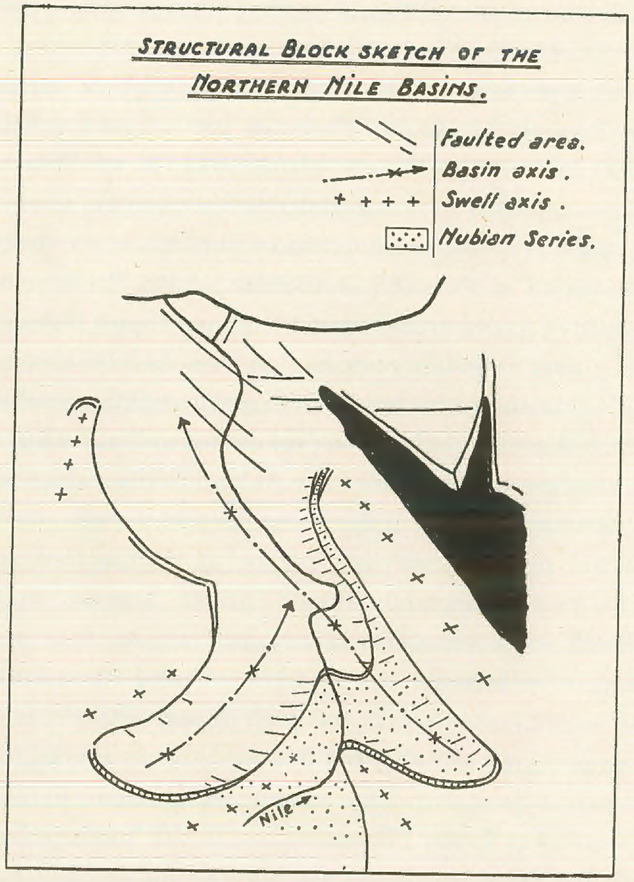
Still, as mentioned above, the almost complete lack of other than the local coarser fragments in the conglomerate portions of the Nubian sandstone seems to indicate that the peneplanation of the pre-Nubian base was fairly complete and that no accidental relief allowed an energetic water-transport of pebbles. We are therefore inclined to assume that the broad basement outcrops in the cataract portions of the River generally and especially south of Aswan actually are indications of post-Nubian warping. Some faulting took definitely place in that area, and besides we know of some young volcanism in this vicinity. Since most of the (probably upper Pliocene) humid rivers of this area (mentioned on page 169) occur at a level corresponding to the base of the Nubian Series, which means that in this time the basal portion of the Nubian Sandstone was nearly stripped of its cover but not yet deeply eroded, we can assume that one warping period seems to have begun in Upper Pliocene time and appears to be present still, although sometimes interrupted and sometimes accentuated.

Such changes in internal activity have occurred for a longer period already and simultaneously with the prelude and with the main periods of fracturing in Egypt and the Red Sea field that is the U. Cretaceous, Eocene-Oligocene periods. The second accentuation would begin in probably Miocene or Lower Pliocene times, in the North and outside our area causing the rapid incision of the Nile bed up to the Idfu-area coinciding with events, which finally brought the sea into the pre-formed lower and middle Nile valley proper without allowing to heavy (if any at all) a discharge of Upper Nile-waters into the marine Nile-branch. This would have lost its marine character if much fresh-water was discharged into the newer channel.

B. The Middle and Lower Nile Section and its Tributary-System

1) *The Structural frame*

We begin with the description of the bigger structural back-ground. (See block diagram).



Block diagram.

The two biggest basins of Middle and Lower Egypt are represented on the geological map by the conspicuous distribution of Eocene limestone formation and their southern Nubian-sandstone projections especially

the Nubian sandstone-spoon protruding to the S.-E. from the vicinity of Idfu. While the Northern depression, according to the Miocene shore indentations (Chata, 1953) N.-W. and N.-E. of the Baharyia-spur accentuates itself in younger (Oligocene-miocene) developments and strikes axially in a fairly straight N.-W. direction, the southern and slightly smaller basin branches off the Northern one in the Quena-Luxor area, with a slightly crescent-chaped S.-W. axis. Both combined display the same sigma-shape as—in greater scale—the whole Nile-Basin system and the Eastern Indian Ocean Depressions S. of the zig-zag swell-arrangement.

The Middle Nile gains the axis of the Northern Basin near Kom Ombo and follows it down to near El Minia, the area where a Basin-axis-sub-parallel fracture zone (which characterises this particularly tensional portion of the lower Nile basin) meets its course. It is here, where—as we shall see—the conspicuous N.-W.-minor-fracture system in the tributary-complex of the master-stream, after a strong accentuation, is replaced by the structure fan of the Minia-Cairo stretch. The river then and there leaves the basin axis taking its new N. and N.-N.-E.-course towards the Fayoum-area until it reaches the lowest portion of this fracture field at the southern point of the tectonic Delta Triangle. We are going to discuss this area separately (p. 182)[1].

This lower Nile-Basin portion is comparatively simple with the exception of the Luxor-Quena-bend, which is not due (as suggested by previous authors) to a «dome» or fold in the vicinity. No such folding structure could be observed either from the air or from the ground.

The attitude of the Nile portion further upstream is peculiar. Before entering the Northern basin it avoids the S.-W.-Basin and flows alongside the S.-E.-«roof» of the swell which borders the southern basin towards S.-E. The Nile—in this area—behaves as the Wadi Quena does further North, when this last-named drainage glides westwards down

[1] We shall not discuss the youngest history of the Nile during and after palaeolithic times. In this respect we rely on Sandford Arkell and Huzzayin, whose remarks (esp. Huzayyin, p. 152/153) on this subject and partly concerning our problems are reasonable.

the quickly elevated flank of the Eastern Desert mountain echelon without reaching the Basin-axis for a long distance. The block diagram indicates this development.

This behaviour of the Nile in the Kalabsha Aswan-portion in itself proves to our mind the rather youthful accentuation of the tectonic contours between the present Nile and the limestone-basin in the N.-W.

The southern reaches of the River have been dealt with in a greater frame above (pp. 166-172).

2) *Medium-sized and Minor Structures and Movements*

Before beginning with the evaluation and registration of the minor linear drainage elements, a revision of the known medium sized « acute » structural features of the Egyptian Nile basin-systems may be summarized. « Acute » structural features are ruptures, that is indications of tensional, torsional or shearing stresses exceeding the strength either of 1) a rock-layer or—and this question is important—2) the whole cover-system of Nubian series and calcareous and marly « blankets ». Whether both reactions show the same attitude, can be solved if the strain-indications in a number of beds clearly fit into the greater mechanical plan or scheme-unit or units. Since, along the Nile-valley numbers of consecutive beds are exposed (see Photos), a structural map of the area must show, whether minor structures throughout the heterogeneous complex are of value for the analysis of the whole tectonic unit or not.

We inventorize and discuss the fault-system and fault-like systems first.

We come to these fractures within the broad, smooth units of the Northern and Southern Nile Basins resp. their margins. The apparent faults alongside the Nile valley are well known. A number of controversial ideas about them have been discussed in the past. The question whether they are actual tectonic phenomena or huge landslides could not be settled for a long period (Beadnell, 1900; Lawson, 1927 and others). Although the authors cannot prove their view by a definite and « meter by meter » observed cross-section through one of these rotated

« kernbuts » (Lawson, 1927), they are, from geometrical deduction as well as from many minor observations especially in the vicinity of the Valley of the Kings, from the West of Quena, from the Guiza region, from the Red Sea Coast, and minor rotation faults within the Eocene complex, where-ever its equilibrium is disturbed especially in its « scarp-regions », convinced that such « faults » are mere spoon-shaped or shovel-plane rotation planes. They are movement-surfaces along which the competent Eocene Limestones have been brought down to a new rest gliding over the (sometimes in the past slimy) top portions of the basal Esna-Shales-facies. It is of some interest to note that such developments do not only need a fairly deep erosion of the adjoining valley but, besides this exaggerated slope, an additional lubrication of the Esna Shales by either subterraneous water-reserves migrating on the top of the impervious Facies or by rather humid climates with a fair and broad infiltration of surface water through the covering limestone plateau, thus creating subsurface lubrication. Since, usually, marine resp. non-marine Pliocene is covering such features, while elsewhere Pliocene itself is involded in the sliding (Pyramids-area, Guiza), the period during which it occurred must have been fairly lengthy [1]. That such rather humid periods occurred during this evolution has been indicated above.

We shall mention these events later again, but personally we are sure that no proper tectonics are represented in this huge landslide of a « paratectonic » outline or size, as Omara (1953) calls it.

Minor structural phenomena do sometimes pre-destine or outline the limits of such rotational « para-faults » and their shape.

Real structural details are known (or marked in the local literature resp. on the geological map of Egypt) only at very few places. They can be inferred (besides the information mentioned) sometimes by very outspoken linear arrangements of scarps, basalt occurrences and so forth. Their regional distribution indicating a—sometimes rather complicated—stress-combination seems to be as follows; North-East of the

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[1] We do not consider similar features near the tectonic boundary of the Delta, found recently by U. Jux and dated as late Oligocene or early Miocene (personal communication).

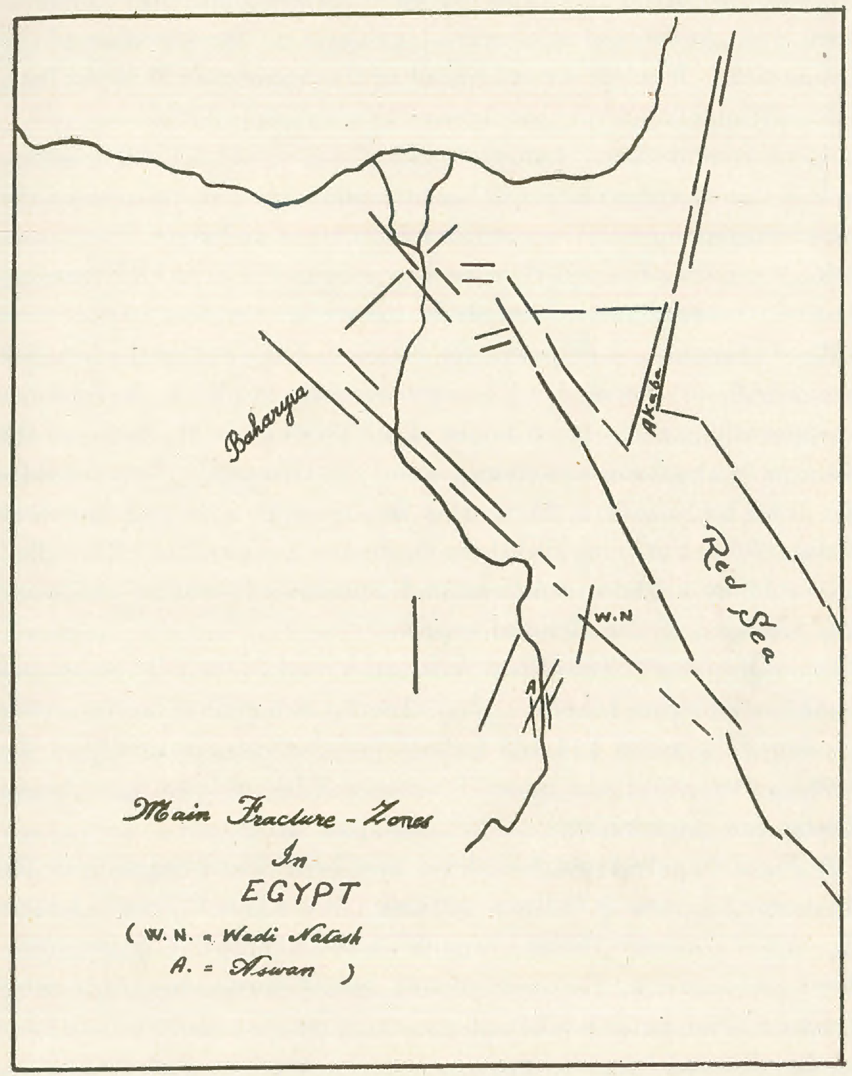
Quena-Luxor bent the major linear tectonic directions point uniformly N.-W., and the minor features displayed in our diagrams (see Diagram chart n° 1) show the same attitude. South of the Luxor-Quena and in the bend itself the minor features point N.-E. and N.-W. Possibly the North East-grain is more pronounced in this area. This concerns visible fractures. If this is true, it would mean that fracture within the N.-W. oriented North Nile-basin run more or less sub-parallel to its axis. Tension-Fractures of the same size seem to be more confined to the E.-N.-E. limb of the basin, that is to the strongly inclined calcareous Eastern Desert. This seems reasonable. It should in this respect be borne in mind that we came—above—to the assumption that at least some of the minor swells (Bahariya) were formed as compressional features or a mechanical representation of the folding elements of a more northern and structurally different area.

This swell bordering our Northern Nile Basin in the W. indicates—if it is created by a lateral compression (compare p. 165)—a local increase or climax of tangential forces (and this at 45° to the trend of the basin-axis). It is here, in its northern portion, where the basin-axis is marked by clearly tensional (or shear) features, Graben and basaltic eruptions belonging to the tensional system just described from the Eastern Desert and now trespassing to the western limb of the Basin. It is—in still greater scale—the Wadi-Natash-Quena-Assyut line just touching the Northern point of Baharyia, parting the northern folding belt from the swell proper. We regard this line as an important boundary. It bears the Wadi Natash-post-nubian igneous complex at exactly the site, where the N.-E.-Akaba-line crosses it after leaving the Eastern Desert basement.

There are indications towards the conclusion that, the (clearly tensional or shear) basin-axis-subparallel faults are arranged partly more or less parallel to the direction of the greatest compression, partly at a «shearing» angle to it. They may be due to the same evolution producing the «bottle-neck-effect» which is created by the Baharyia-swell upon the Northern Nile basin by narrowing this basin considerably.

Where, further south, the Baharyia swell broadens and disappears in the sub-surface (Picard assumes—probably rightly—its presence in the subsurface), the basin-axis-subparallel faults disappear as well (west of

Assyut) from the surface. The basin itself widens towards the South and the basalt lines dwindle. The line just indicated gains in importance further south (Wadi Natash Foul Bay).



Map n° 4.

This line forms definitely the mechanical boundaries between : *a*) the elevated Graben-frame of the Eastern Desert, *b*) the more stable portion

of the shelf in the S.-W., and c) between the Baharyia *swell* and the *folding* belt in the North.

A detailed mechanical explanation cannot be given as yet. It shows tensional (or tearing) elements in an otherwise apparently compressional unit, however at a «reasonable» angle in the direction of the compression. It might be mentioned in this connection that the Paris Basin, although displaying local tension also is explained by Cloos (1933) to be a compressional feature [1]. Eardley (1950) on the contrary explains his American Basins rather by tension. So the question on the whole remains open. We may have both types of basins.

Concerning the time-question we may refer to the hypothetic synchronization of several tectonic events in the region on page 167.

Minor structures were practically unexplored in spite of the fact that they actually ask for analysis, being beautifully displayed (for instance near and within the rock-cut-tombs of the Pharaohs in the Valley of the Kings or in the Nubian sandstone along the railway-line between Idfu and Aswan). Seen from the air they sometimes give the vast limestone plateau the look of being slightly be combed in one direction. This effect is created by slight undulations and pronounced jointing producing little erosional or denudational scarplets.

Drainage patterns accentuate such grain marks especially under arid conditions (compare Lobeck, 1939). Locally such grain is inconspicuous or covered by sands and late tertiary gravel sheets, especially in the Western Desert. These minor features will be analysed in a special chapter (see page 185).

Few *actual* or doubtless fault lines have been discovered sofar in the Southern Egyptian Nile-Basin between Aswan (S.-E.) and Kharga (W.-W.). We know of the Kharga-fault and Kharga-flexure (or monocline) mentioned by Beadnell (1900) but of hardly any other acute structure in the vicinity, although some very conspicuous structural lines can be observed from the air.

[1] v. Bubnoff's thesis (1938) that with every compression in a certain direction we find a tensional effect normal to this direction may altered into : normal or oblique (at shearing angle) to it.

Most of them seem to run partly N.-W., partly to the S.-W. and some of them strike N., especially in the Aswan-portion of the Nile Valley, in Kharga Oasis and its northern projection reaching the Nile near Deirut.

The development of N.-E. structures along the S.-E. margin of the southern basin seems to be likely; in the basement outcrop they are as clear as the N. structures.

The axis of this southern basin is more crescent-shaped than the northern basin axis. Torsional forces seem to be involved here also. It has already been mentioned that both basins combined show the same flow-type-arrangement as the Indian-Ocean-basins. South of Aswan the basement is disclosed for a certain distance. The N.-E. structures invite a short summary of basement structures of the neighbourhood. It shows structural features which are being analysed at present.

The grain of the old complex is mainly S.-N., locally slightly deviating towards N.-N.-W. or N.-N.-E. Some probably paraphoric (or tear-) faults show a curved N.-E. trend. Dykes of several orders, age and chemical character dissect the metamorphic matrix which consists mainly of irregular schistose, often gneissose layers in intercalation with igneous intrusions, apparently immigrated along more or less horizontal, probably mainly tectonic surfaces (E. Wegmann, 1952). The dykes appear prior to and after bosses of igenous, mostly acidic rocks. The whole system is fractured several times; at first, probably soon after the immigration of the grano-diorite-sill-like or lacolithic masses, for the last time (so-far) in post-nubian times. This youngest distortion apparently was corresponding to the warping-up of the basement portions creating the Nile cataracts [1].

These paraphore-like zones have been used again and again, vertically in late—or postnubian periods and especially laterally in previous, probably late orogenetic times. Particulars will be considered in a work dealing with structural development of the basement group of this particular area. It is very conspicuous that these basement structures govern

[1] The possibility of explaining these basement-stretches laid bare by the river course as being pre-nubian basement-elevations has been mentioned in pp. 166, 167, etc.

(as anisotropy-elements) numerous structural lines in the covering sedimentary blanket, especially in the Nubian series.

So the Nile, when excavating its bed in the Nubian series, already had « notice » of the basement grain, to which it partly readjusted its course after reaching basement bedrock by preferring old shatter zones (with a definite lateral displacement and some with igneous, but prenubian fillings).

The Nile of this portion is definitely a superimposed river, developed in the Nubian « blanket ». That the river now closely follows basement structures may be—as just mentioned—due to the fact that most of the basement structures are projected (inherited) in the Nubian cover. Probably both explanations can be combined, since the Nile bed carved out in purely Nubian Series North of Wadi Halfa often displays remarkably straight stretches actually running parallel to the (inferred) basement grain.

This leads over to a genetical consideration. Minor structures will remain to be analysed later, but only in connection with the tributary system of the master stream.

3) *Genesis of the Middle and Lower Nile River within its structural control*

The drainage towards the Nile is « tributary » to the master stream. This implies that its development depends generally on the evolution of the Nile proper as a base-level for its surroundings. We shall see, however, that, at least in the lower Nile reaches, some tributaries might be older than the present Nile bed itself. We know of the existence of a deep valley where the Nile flows now in pre-Middle Pliocene time (Beadnell, 1900; Blanckenhorn, 1901; Lawson, 1927 etc.). Some authors are of the opinion that the Nile must have cut its first bed probably in late Miocene times although no miocene deposits are known at present in the Nile valley. This question however is of secondary importance since for our tectonic developments it hardly matters, whether the excavation took place in late Miocene or in early Pliocene times.

The distribution of Oligocene estuarine sediments and marine Miocene in Lower Egypt might indicate a Nile-mouth within the area between Baharyia and the Fayoum. This ancient Nile must have been a broad meandering and perennial river without a marked erosional bed. We have mentioned the existence of a similar drainage for Oligocene times already.

We may assume that the river entered the present-day delta region only after its tectonic formation, which would mean later than Upper-Oligocene times. Another factor to be considered is that the Delta-collapse in all probability took place below sea-level, that is prior to the regression of the sea, so that the river-erosion could not take place before the area was dry land. This however occurred probably either in some period in Miocene or only in early pliocene times. These regressions mean automatically an accentuation of relief-energy. We might mention in this respect that some of these regressions were reversed and might possibly be eustatic (?).

The excavation of the pre-marine Pliocene Nile bed should definitely be attributed to river erosion, although Lawson (1927) and others strongly object to this assumption (compare Ball, 1910; Hume, 1910; Breasted, 1909; Krenkel, 1925).

The controversy—tectonic origin of the lower Nile valley or erosion—solves itself, as soon as we define it (as often is such discussions) : « structure *and* erosion ». Structure in this case means « Graben-like » Delta Unit [1] and tension faults of varying throw up to Assyut, and, in a diminishing degree to S.-E. of Kom Ombo. We agree with Lawson (1927) that the lower course of the Nile might have been captured by the fracture zone but we do not agree with his dating the Delta fractures in post-Pliocene times since, to our mind, the Delta fractures are contemporaneous with the basalt-eruptions near Cairo; these basalt-eruptions are Oligocene or Miocene in age, as the Gulf of Suez is.

[1] Delta-unit in a double sense of the word : 1) a « settled » keystone; *b*) a triangle corresponding to the Sinai-triangle, only with the difference that Sinai is elevated (its boundary-faults dipping away from the unit) and the Delta is structural low-land (the border-faults dipping towards the unit).

Therefore this capturing should have taken place earlier than Lawson's date and as pointed out above as soon as the submarine fracture zone rose above base level, that is between Miocene and Pliocene or in Lower Pliocene times. The question, whether the first erosion events in the present Fayoum may date back to this time (the Fayoum later being converted into a desert-depression proper without stream erosion) seems to be worth while investigating. The Fayoum may thus prove to be a portion of a catchment area of a first Delta-governed river which later-on captured the Nile. This Delta-River could have drained the area to the N.-E. of the faint but conspicuous warp bordering the Miocene indentation (Chata, 1953) N.-E. of Baharyia, that is the area of the Fayoum, Wadi Hof-catchment-area, event the drainage lines S.-E. of Beni Suef, coming from the South Galala Plateau district.

This also is still a question and a hypothetical assumption.

If we deal with the whole structural development of the Egyptian Nile area we can conclude point after point : The development of a new river system needs the elevation of the (formerly submarine) land-surface. This took place for Lower Egypt in late Miocene times. It coincides with the general accentuation of relief in North Africa («geocratic period» of Bucher 1939) after the previous thalattocratic period. While the thalattocratic period of our area began in early Nubian-sandstone-times with the formation of a widely extended shelf sea, the first lasting elevation took place for Middle and Upper Egypt in post Upper Eocene times (see Cuvillier's palaeogeographic map and Picard 1943). It is advertised generally by the heterogeneous, disturbed looking U. Eocene sedimentation and other features indicating the following «clastic period» (or greater endogene or internal or tectonic control of sedimentation) and the corresponding fractures, warps etc.

For the development of a «new» river we need, furthermore, water draining some southern hinterland and a collective run-off. The collection of the run-off was done by a greater structural frame as we have seen. Indications of the hinterland drainage have been reviewed (page 169).

We summarize again for the Egyptian portion of the Nile : the tremendous amount of (possibly) Oligocene and (or) Miocene clastic series with well rounded pebbles [1] indicate in their own spectrum as well as in the spectra of the heavy minerals carried along with them (Shukri and his school) a gradual elevation and stripping of the hinterland first of flint derived from the denudation and erosion of the young limestone cover, later-on of Nubian sandstone and then basement formations (Shukri, 1944-1945), if the latter was ever covered entirely which may be doubted (compare Cuvillier, 1930; Andrew, 1937).

This evolution apparently produced gravel fans and shallow meandering also of probably perennial stream courses.

The Middle course of the Nile might possibly have been situated in the neighbourhood of its present channel. It makes actually no difference in this respect, whether its water derived from far south, or mainly from Upper-Egyptian catchment areas (Wadi Quena, Kom Ombo, Wadi Zeidun etc.). The present-day lower Nile, that is the river course downstream of Maghagha area was apparently not situated where it is now until late miocene or early pliocene times. We mentioned this in pp. 181-182.

Before that date it might have aggraded a course following the axis of the lower Nile basin and possibly discharged into the sea not far off the Fayoum (compare pp. 180-181).

We assume, in the following time, a rapid incision of the Nile-bed together with a contemporaneous sinking of the base level and a diminution of the rain-fall which put the wider Fayoum-catchment out of action. Its later overdeepening should be attributed to other causes (compare pp. 197-198). We can therefore assume the existence of smaller streams of more local origin before the big drainage governed lower Egypt.

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(1) It is true that hardly any of these gravels can be proved to have been worn along the contemporaneous drainage lines. The flint concretions are naturally smooth, the smooth quartz pebbles might come from a conglomeratic bed in the Nubian series... The wide distribution of gravels however together with fossil wood and a fossil fauna show clearly the existence of a humid climate and consequently of perennial streams.

III. TRIBUTARIES OF THE NILE

The present-day-tributaries are very pronounced in the East, very inconspicuous in the West. The reason for this difference must be searched for in the different velocity of the run-off-water West and East of the River. The inclination was stronger and ever increasing in the eastern portion since the moment of regression of the sea from these reaches, while in the western plains no water-activity could be developed : *a*) for lack of generally sufficient inclination ; *b*) for the prevalence of porous and easily infiltrated strata, as represented—at least in the Northern portion of the Western Desert—by the Oligocene-Miocene gravel cover.

Some tributaries of the Nile accordingly flow over bedrock, some over gravel plains. While the first-named drainage-lines may be influenced by—mostly inhomogeneous and mechanically anisotropic—country-rock, the last named mainly obeyed gravity and turbulance. Or in other words, such rivers do follow the general inclination of the country but do not make use of structural features. If they excavate, they are converted rapidly (depending on the situation of their base level and the thickness of the clastic cover) into streams of the first-named type and adjust themselves to structure. The younger bed then differs markedly from the high-level course.

The tributaries concerning our minor structural problems directly are generally young. We anticipate that the Oligocene Miocene tributaries were humid rivers, which in all probability meandered for several reasons.

Our present day tributaries are wadis. They do not meander but they may be descendants of the old systems mentioned before. These young tributaries have cut their way into the country rock and try to reach (have partly reached) the base level of the Nile. Some of them are « drowned » as a portion of the lower Nile is, by young sediments. We know nothing or very little about their attitude during the marine and post-marine pliocene interval but we may assume that—since the narrow Nile-Gulf was actually marine—they can not have played a very pronounced role as far as the quantity of water is concerned which they brought down to the Gulf. Otherwise the Nile-Gulf-water would have been

brackish or fresh and the Gulf filled in by their sediments. We may therefore assume a comparatively dry climate for this time also.

Such dry rivers might have been activated during some moist intervals ; some of them actually display typically humid and well worn pebble beds, for example the lower Wadi Quena and the Wadis East of Lageita Well on the way from Quena to Qoseir ; but in all probability either at a pre-marine early pliocene or, more likely, at a late-pliocene period, that is after the marine intermezzo.

These rivers have, as soon as their incision reached competent formations, made use of lines and zones of least resistance. They therefore display to a certain extent structural feature of the country. This concerns mainly : *a*) tributaries of the calcareous plateau, never covered or not anymore covered by clastic sediments ; *b*) tributaries within the Nubian sandstone area which was originally covered by the clastic facies of Upper Cretaceous and Eocene times ; *c*) tributaries within the basement formation proper. All of them have probably been created as superimposed rivers, but we have already seen that rivers do adjust their superimposed courses as soon as they meet with only slightly deviating structures of basal formations. So the Nile itself is partly superimposed and partly later adapted to the basement structures. We pointed out that even where its original « rails » have been determined by (now cleared) Nubian sandstone we might bear in mind that a great number of Nubian-sandstone structures are inherited from its base (page 179-180).

In fact, beautiful examples of inherited minor structures of this sequence (basement + Nubian sandstone) can be observed anywhere between Wadi Halfa an Idfu. They actually invite a special investigation on experimental lines (as tried in 1939 by M. Ekkernkamp).

IV. TRIBUTARY EROSIONAL LINES, THEIR EVALUATION AND THEIR STRUCTURAL MEANING

Since as mentioned above, major smooth structures actually control the drainage of Egypt, major acute structures are—at least in the Nile Valley—not conspicuous. They are represented mainly by a sum of

millions of minor and minute cracks, joints, distortions which compensate the internal tension of the « rock » to an equal amount, as elsewhere a fault, a flexure, monocline a graben does.

We are therefore confined to the evaluation of minor structures. It has been mentioned above, that this evaluation shall take place by a « natural exaggeration », that is by means of checking the directions of the secondary drainage lines dealt with above.

This eliminates to some extent the objection that structures in competent series intercalated with incompetent material are uncontrolled and irregular. Since the reactions of competent beds may be somewhat obliterated by the plastic or flow-reaction of the incompetent members of such systems.

We know, furthermore, that especially the marls and clays of Egypt did preserve for a long time—and even preserve it now—a considerable portion of their original marine salt-content. This renders them still more plastic, as is to be observed in the clay-glaciers of the Mokattam area (Knetsch, 1953) and other structural or external developments of the country. So, minor structures should be regarded rather suspiciously in such regions.

Our drainage-lines, especially those of the eastern (calcareous) desert dissect a whole series of intercalated competent and incompetent beds.

The direction of an erosional element is determined by the flow of water on one side, and, on the other hand by the resistance offered to this flow by the grain of the underlying formation. The flow-direction corresponds mainly with the inclination, since it is governed by gravity. The resistance of the underlying formation is stronger in some places, weaker in others. This difference is created by the attitude of the beds, that is the structure, dip and the lithology resp. facies. The actual talweg of a drainage-line is therefore mainly a resultant of a number of not always fully understood factors. Not fully understood means that especially the climatic past adds some question-marks since a perennial river behaves differently from a periodic-one, which in itself differs from an episodic wadi. This should not be forgotten. Therefore, the ideas offered below are not always without doubt. Such considerations naturally influenced the method applied.

The statistical side of the analysis was somehow tricky. We made use of a number of foreign publications, especially the deductions of Pincus. Dr. Simaika of the Department of Statistical Mathematics, Faculty of Science, Cairo University joined in our considerations and helped a good deal. We take the opportunity to thank him here also.

We came to the following conclusions : the 1 : 100.000 map of Egypt, especially of the regions in question has been locally checked on the ground and by means of aerial observations. It was found that, on the whole, the map is fairly reliable and suited for the work in question with certain precautions.

We selected linear stretches of the drainage lines which were longer than 500 m., anticipating that possible errors in the map could be eliminated in that way. Furthermore we are dealing with a stretch near the Nile, that is near cultivated areas, which in all probability are more reliably mapped than far-off desert regions. The figures (altogether 32.700) have been drawn in direction diagrams covering 10 square kilometres each.

An original-sized drainage-map with its first direction diagrams is shown in diagram chart n° 2.

Several trials as far as area-size etc., are concerned did show that this scale was suitable for the regions in question. General direction diagrams over greater areas as tried at a preliminary stage of this work comprised regions of different tectonics and showed rather inconspicuous or disturbing results. We tried them over the whole Nile, covering the single basins, covering different country-rock, basement, checked them in Sinai, along the Red Sea coast-line and adjusted our results correspondingly.

The results obtained by several of such trials, condensed in the way to be described below, show by their general distribution and prevailing directions enough definite lines to prove a certain value from the structural or analytical point of view. The summary of this chapter will point out the results.

Furthermore, a selection according to the country rock was discussed as for instance for the Nubian-sandstone-areas, the limestone formations, the Oligocene-Miocene clastic « blanket » in the North.

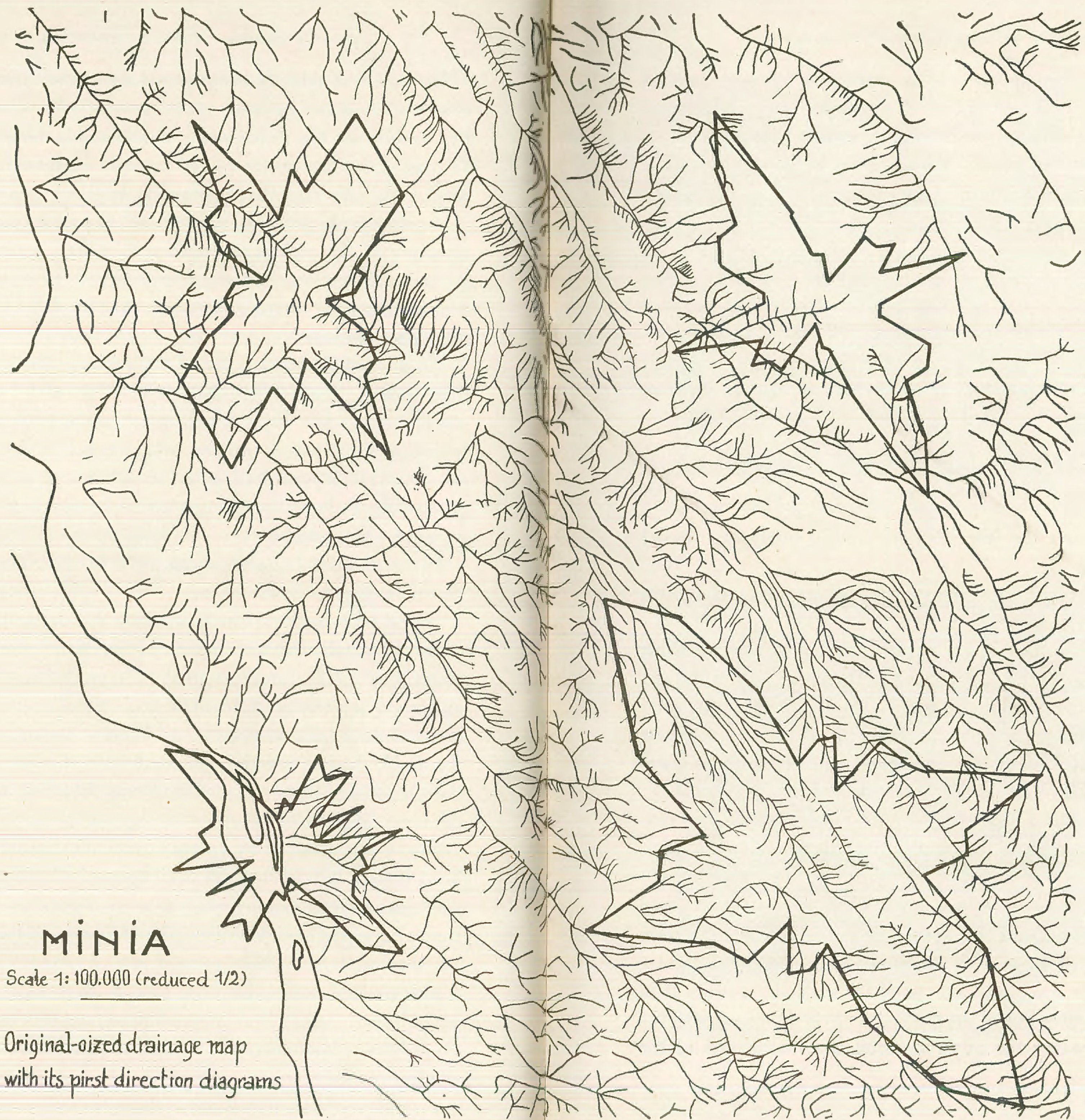

Diagram chart n° 2.

Selections of this nature appeared to be reasonable but were omitted to show actually the different value of drainage-lines as structure-indicators in the heterogeneous and anisotropic « matrix ».

Areas covered by young gravels do—as the diagram-map shows—display a partly obliterared picture. Still, contrary to expectations they *do* show something.

The map therefore shows a varied picture of sharp and clear, of « translucent » and « opaque » diagrams. Special features shall be discussed.

The serial photographs (photos 1 to 4) speak for themselves.

Altogether we have used 23 topographical maps (scale 1 : 100.000) of Egypt comprising the area from Cairo to Aswan, that is the area between.

Latitudes : (30°16′12″ and 23°40′30″).
Longitudes : (30°13′30″ and 33°0′15″).

From these maps first the Nile itself with all its confluents (wadis) was copied.

The area of each 1 : 100.000 map was divided into 6 equal squares of 20 × 20 sq. cm.-400 km².

Of all tributaries contained in any square, the length corresponding to direction intervals of 10 degrees relative to the North (from 0 to 10, from 10 to 20 etc.) has been measured by the following procedure : for fixing the North at any place of the transparent paper map-copies we placed beneath the square a sheet traced with sufficiently dense system of parallel lines placed in the North direction.

A graduated circle of 360 degrees was used. The line through its centre joining 0 and 180 degrees has been divided in parts of half a centimetre each.

Any confluent was divided in portions which could be considered approximately straight lines. For determining the length and direction interval, to which any of these straight line elements belongs, the centre of the graduated circle was placed on one of the ends of the element in such a way that the centre line of the graduated circle coincided with the line element. By reading the angle between the central line of the

Photo 1. Erosional lines in basement-formations closely following structural pattern. (Background Nubian Sandstone) Aswan area.

Photo 2. Erosional system in U-Cretaceous beds captured by Wadi Qena (foreground). Nubian sandstone-joint system (arrow) show the same directions as displayed by back-ground wadis draining U-Cretaceous beds Northern portion of Qena.

Photo 3. Tributaries in M-Eocene Limestone NW-strike of slightly warped beds. Bedding-plane-outcrops. Cross joints (SW-NE) and Diagonal-joints (NS) control the Erosion.

Photo 4. Rectangular drainage-pattern in U-Eocene strata Upper course of Wadi Hof.

graduated circle and the line of the parallel-line system which passes through the centre, the direction was determined.

By means of this procedure we have tabulated for the confluents and the part of the Nile contained in each square of 400 sq. km. the total lengths belonging to the 18 direction intervals. The results have been tabulated and then represented graphically by rose-diagrams for any square.

The total area is covered by 120 diagrams (the square which contain no confluents have been omitted). It corresponds to an area of $400 \times 400 = 48.000$ sq. km.

There was a certain difficulty in arranging the resulting diagrams on the map, since the size-difference was considerable. Therefore we reduced all of the diagrams to the same size and gave an indication for the reduction-scale.

Having found a maximum of 80 length-units (1 unit = 1 cm.) we have used diagrams corresponding to 4 length intervals :

1) 0 to 20 cm. ; 2) 0 to 40 ; 3) 0 to 60 ; 4) 0 to 80.

The four corresponding rose-diagrams are, as mentioned, reduced to the same size. The four different intervals are indicated graphically by the number (1 to 4) of concentric circles.

Concerning these figures we arrive at the following conclusions :

A preferred N.-S. Orientation is being observed in the Aswan-Idfu-stretch. We know that the grain of the Aswan-basement-formation is approximately N.-S. with slight deviations. The direction-rose of this portion shows a number of rays. The north-pointing arrow is the sharpest one. Other direction might be numerically equal, but they are somehow obliterated. These other directions show the main-fracturing scheme (and dyke-scheme) of the basement.

We have tried to construct a complex strain-ellipsoid into these diagrams. It is possible and perfectly clear as far as its longest axis is concerned. Since although, the basement-distortion is too intricate and partly exaggerated by lateral events, we did not reproduce this interpretation here.

It can be observed in the field as well as on aerial photographs that

basement-structures are clearly inherited and truly reproduced in the «Nubian blanket» (compare photos).

It could be assumed that at least some of these structures were created after deposition of the Nubian series, but field investigations (Hume, 1925; Andrew, 1932 and others) show clearly that only slight deformation including some faulting occurred after the sedimentation of the Nubian sansdtone. Since the Nubian series in the area in question consist of a series of intercalated competent and incompetent beds, the question concerning the reliability of minor structures as to greater tectonics is at least locally and positively answered.

The area just discussed shows—as mentioned—N.-W. and N.-E.-«rays»; the N.-W.-direction grains ground the more we proceed further North. There is a gap between Quena and Girga, where, coming from S.-E., a broad band of N.-W.-lines approaches the river. It crosses the river near Manfalut, near the first,—apparently N.-W.—oriented basalt-occurrences. Downstream Beni-Souef the direction turns E.-W. end produces a fan-shaped figure of rays, which bend slightly N.-W. west of the River.

E.-W.—directions are typical for the Q—or cross-system of the Aswan-basement. They also trespass into Nubian and reach Idfu and stop at the Southern margin of the Eastern-Desert-Upper-Cretaceous. Quena-Nag Hammadi shows a slight E.-W.-component, which gets conspicuous again at a point near El Wasta, approximately at the place where the West-projection of the great Sinai-East-West-fractures crosses the River. The E.-W. component continues until North of Cairo but is more conspicuous on the East-bank of the Nile than then West of the River.

N.-E.-fractures govern a portion of the Aswan-Esna-portion. They may be the direct projection of the Gulf of Akaba-line being represented south of Aswan by great tear-faults (paraphores) in the basement-formations. Most of them show—south of Aswan—an apogranitic (aplitic) dyke-filling proving the great age of such structural base-lines

The N.-E. structures, that is the Gulf of Akaba-direction appear conspicuously only south of Luxor.

Further North the direction appears again between El Minia and Cairo.

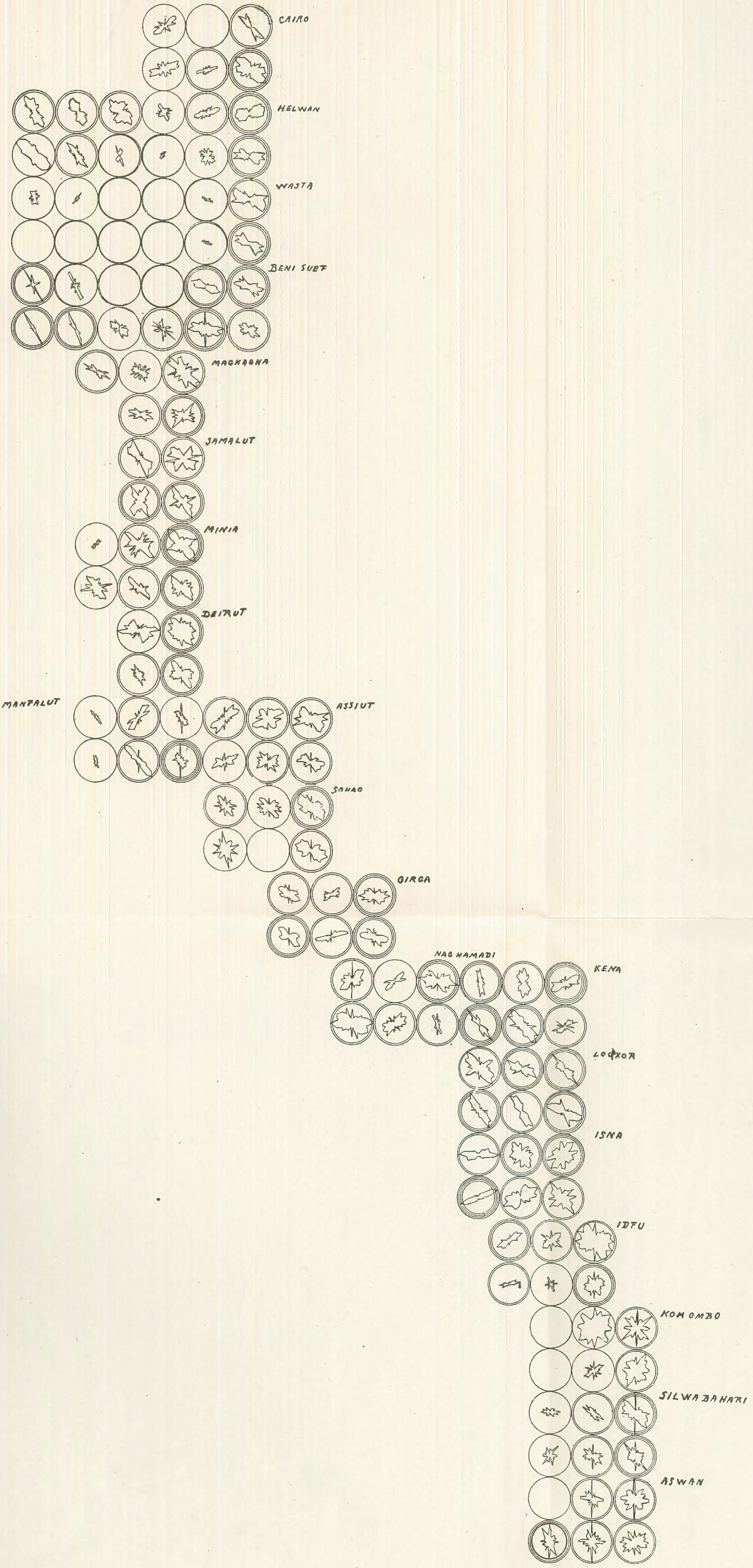

Diagram chart n° 1.
Diagrams of Tributary-Directions between Aswan and the Fayoum.

Generally, the structural orientation shows, as far as the Nubian blanket is concerned, a strict parallelism with the structural grain of the basement.

It can safely be assumed that this inheritance goes even through the Upper Cretaceous and Eocene covers, where, directly North of Kharga(?), this grain again appears in the Nile Valley. The conspicuous N.-W.-tension faults which cross the river from S.-E. to N.-W. near Manfalut, maintain their trend irrespective of the thickness of the cover but, this line is definitely young (post-Oligocene).

On the whole, the picture is interesting, shows a remarkable parallelism of major and minor structures and proves that even in a composite and heterogeneous sedimentary complex the parallelism between major and minor tectonics remains preserved.

It is furthermore sure that—at least in our country—drainage-lines may successfully be used for the determination of the structural grain even in only slightly deformed regions.

V. STRUCTURE AND ORIGIN OF OASIS-DEPRESSIONS IN THE WESTERN DESERT

The structural meaning of linear structural and—as a result—morphological elements has been discussed. We have found major epirogenetic or rather dictyogenetic (Bubnoff, 1938) elements, swells, warps, etc. as a tectonic frame of first order, as far as size is concerned. We found the same genetic type in smaller outline and we have noticed the important role played by the fissuring of rock-units in the following morphogenesis of a prevailingly dry country. Faults proper, meaning parting surfaces with a definite differential movement of the separate units, were of great importance in genesis and shaping of the lowest Nile valley although no Nile-Graben proper exists, while joint-system influenced mainly the tributary-system. The joint-systems were subject to and created by the same regional distortions as faults and warps. So their analysis leads to the same results as the investigation of major structural elements. It seems to be of some interest to cast a glance at the influence

or non-influence of structure on the formation, situation and shape of the Oasis depressions in the Western desert of Egypt.

The discussion about the origin of the overdeepened Oasis-Depressions in the Western Desert has been going on for many years time.

Previous authors offered different and varying opinions. The idea of wind erosion, or rather « corrasion » (active scouring by sand-carrying wind), an assumption of purely structural development (down-faulting) and other, combined, explanations have been offered sofar.

From the view-point of the present investigations the problem may be discussed as a side line.

The laterally irregular depressions are more or less all-round closed, although in some cases, the Western side seems to be more open than the other directions. The Bahariya-depression at least shows furthermore a structural orientation : it is situated exactly on the spot where the Baharyia-swell (which branches off the Tibesti warp and which is apparently partly obliterated by the younger cover) disappears, or better where it is replaced in the same, curving projection by young (late-or even post-miocene) folds belonging to the Syrian arc (Krenkel, 1940) showing the same N.-N.-E.—axial trend. This mechanical—or style—replacement is, as mentioned on page 165 certainly of some significance, since the replacement of a vertical broad epirogenetic or dictyogenetic development by folds is unusual. We may assume its origin by some lateral compression. This question has been dealt with above.

Besides, the border line between the swell-plunge and the folding belt proper is marked by the passage of the Assyut-Minia fault-zone (page 176). Its volcanic « association » touches the Oasis itself which displays some, although small, volcanic activity, probably of the same age, as the basaltic events further N.-E.

That means, in fact, that the fracture and the folding belt of Northern Egypt begins at this structural intersection point (compare pp. 176-178).

This evolution would point towards the fact that at least some of the warping-accentuations are not older than Oligocene, while the distribution of miocene shore sediments (Chata, 1953), proves that—in all probability—the warp of Baharyia did exist or was indicated in Miocene times. Picard anticipates in his map (1943, p. 39) the existence of the

Bahariya-swell in pre-Eocene times already. Cuvillier states (1930) the same assumption. In any case, the accentuation occurred apparently in late Oligocene or in early Miocene times.

So we may be safe in assuming an existence of the warp before Eocene and accentuations in later times, possibly synchronized with other structural events, as fracturing (*i. e.* tension), folding (*i. e.* compression), lifting (*i. e.* vertical adjustments towards a new equilibrium of some sort, in other epirogenetics events).

Mechanically it is remarkable that the Miocene shore-line-indentations N.-W. and N.-E. of Bahariya (Chata, 1953) are orientated at the same slightly oblique angle to the swell axis, as the S.-E. faults in the projection of the indentation (between Baharyia and the Fayoum). Both therefore belong to a North-Nile-basin sub-system, which is, on the whole, N.-W. orientated and which is somewhat « bottle-necked » near the Baharyia-swell.

If the oasis depression has some genetical structural background and, if the main structural development or accentuation (warping, folding fractures) took place in this period (Chata, 1953) the external, that is erosional or excavating events must date posterior to Oligocene.

Beadnell (1909) indicates at least partly similar deductions concerning the structural position. When Hume (Cairo Sc. J. II, 24) says that the major depressions of the Western Desert closely follow the trend of the Nile valley (p. 323) he is perfectly right. The homologies of this area are just as astonishing and perfect as the homologies of the African and American coast lines in a greater scale are. It means also that greater laws are in the case and such superior laws indicate themselves by comparatively simple looking structural pattern or arrangement (compare the D-structure in page 164).

The formation of the depression itself is the second step. Since these depressions have no outlet and actually form their own baselevels, a river action can—if at all—only have started the development at its very beginning (Pfannenstiel, 1952). The depressions to-day partly reach down sea-level.

The excavation must have taken place furthermore at a time when the subterraneous water level was lower than to-day, since, below water

level no subaerial excavation can take place, save subsurface solution of soluble rocks, which may be carried away in solution with subterraneous water currents.

Soluble material is present to some extent within all marly and clay formations of the area in question. They contain mainly NaCl, but the suspicion that the solid rocksalt bodies of greater zise may have been intercalated in (for instance) cretaceous beds could not be proved (Hume I, 1925). Although some compact rock salt lenses are actually found in cretaceous beds and as far as we know in some tertiary rocks of the Western Desert also, their accumulations are very small and it is very unlikely that greater accumulations of salt ever existed.

So the solution of soluble beds in the subsurface, although taking place and observed to some extent (especially in middle-eocene limestone beds near the Pyramids of Guiza and in the Mokattam area near Cairo) did certainly play a minor role but could hardly be responsible for the origin of the depression.

We therefore suggest the following hypothesis : Tectonic evolution deformed certain portions of the Western Desert (cf. Hume, 1908; map at p. 322; Uhden, 1932). These deformations took place either as warping as in Baharyia and Kharga (Beadnell, 1908, p. 53) (the other Oasis have not offered any conclusive observations so-far) or as fold anticlines proper (Wadi Rayan, possibly portions of Fayoum as indicated by Chata's map) together with a rather intensive fracturing normal to or at a shearing angle of the anticlinal axis (Wadi Rayan); the Fayoum is not quite clear from the structural point of view, although the anticlines directly northeast and S.W. the Fayoum may indicate a structural development in the same sense.

Beadnell (1905) stated that no down-faulting is connected with the creation of the Fayoum Depression. Fracturing, probably in the N.E. and N.W. directions, is directly visible and besides indicated by the extensive basalt-flows, probably fissure eruptions of the Gebel El-Quatrani and the basalt occurrences in Baharyia. The diagram chart (attached) gives an idea about the main directions.

Faulting is fracturing owing to a disturbed mechanical equilibrium. It may produce a lateral as well as vertical displacement of greater or

smaller amount, but it must not displace, it just releases a tension. Faulting means decrease in resistance of crust but must not necessarily amount to an alteration or differentiation in level adjoining regions.

Structural features of this relaxation type comprise, although seemingly of tensional origin, compressional evolutions also, for instance the anticlinal crest-collapses (strike-or axis parallel jointing and « rueckwaertige» Abschiebungen, Cloos, 1948).

As regards cross faulting, as displayed in the Pyramids area and in Abu Rauwash, it may or may not be accidental that the greater amount of depressions (Baharyia, Fayoum, Wadi Natrun, Siwa, etc.) is situated within the wider fracture belt of Egypt and its interference with warps and folds.

They all are situated at « structural knots», that is in places of complicated distortions.

Such zones are liable to open ways for escaping mobile material. Nearly all of the basalt occurrences in the Palestine and Lebanon fracture belt are situated at such points. We know of the clay-diapirs in such regions, of salt bodies, of occurrences of warm springs (Hammam Pharaon etc.). Such structural « knots» bring the artesian horizon of the Nubian sandstone and its overlapping, secondary roof-leakage-reservoirs (Knetsch, 1952) within reach of the surface and the evaporation. In the meantime the downward-movement of the infiltration water is so liable to find favourable channels here.

Such waters, descending and especially ascending did certainly influence the rocks in question, at least the limestone formations. The ascending artesian waters especially, evaporating at the surface during the arid (by far prevailing) periods produced a strong decaying action upon the rocks in question.

Samples brought in from the maximum level of present Aswan-Reservoir show within the 3-5 m. — capilarity zone above the maximum water level an extremely high concentration of soluble salts resulting in a rapid destruction of the country rock (Knetsch 1953).

We know of the destruction effects of moist alluvial soils of the Nile valley upon antiquities wherever the capillarity rim is reached (Lucas 1925).

We know of the decomposing effect of salt-pans, sabakhas and so forth (Knetsch, 1948). Practically every type of rock or mineral in question, with some exception of quartz (and even the quartz is being attacked slightly) is being destroyed in a surprisingly short time. The result is a moist salty dust, which is easily being carried away by the wind, as soon as the capillarity zone is lowered for some reason and the material dries up. So, a falling subsurface-water-level or its capillarity-halo will be followed automatically by the excavation of the site, that is the formation of a depression, if some transporting agent is available.

This origin, at least the aeolian exportation is attributed to the (Mongolian) depression («Piang Kiang»), also (cited from Bakey and Morris in Cotton 1942).

Development of this sort has also been observed in the Central Saharian Oases where a peculiar way of migration of the cultivated areas from one favourable spot of the Oasis depression to another is being followed as soon as the old Oasis-area is alkalised. It returns to the old site as soon as the wind has cleared the alkalised area. Denudation of this sort is therefore clearly going on even while the ground water level remains stationary. The reason for this type of broad stripping is the efflorescence of salts which lifts them in cauliflower-like masses or indistorted slabs above the moist ground and brings the material at least for periods (daily, annually, etc.) out of the reach of the capillarity zone. Whether this development is sufficient to explain the creation of the huge depressions in question remains still open.

Wind corrasion, that is grinding, scouring, active erosion, takes place as soon as the grain size of a coarse sand gives the saltating grain enough momentum to overcome the air-cushions formed in front of obstacles, but—on the whole—the shaping activity of the sandblast seems to be far less important, as least in the Sahara than in the wind swept costal deserts of S.-W. African (*Namib desert,* Kaiser, 1926, M. M. Ibrahim, 1953).

These actually sand-blast-carved depressions («Wannen») do occur.

The explanation of the overdeeping of the depressions, that is their extent below sea-level on the one side, and the situation of the present subsurface water level on the other hand offers some difficulties for

explanation. It can also be assumed that the subterraneous water level in the slightly North-inclined cover-complex has not always been constant. It is actually assumed that it is being lowered to-day. Theoretically, it can be lowered in two ways :

1) by lack of recharge during dry periods (as it happens to-day).

2) by a lowering or widening of the final ground-water outlet, that is of the submarine exposures of the water-bearing strata together with the removal of sealing beds. This happened at least during the last eustatic change in Pleistocene times by appox. 80 m. (Huzzayin, 1941 ; Zeuner, 1950 ; Pfannenstiel, 1944 and later papers). With the last named evolution corresponds the statement of Sandford and Arkell (1929) which attributes the origin of the Fayoum-Depression to the Pleistocene, that is to point where several sea-level changes took place.

3) Such evolutions should take place (or at least their consequences should still continue, as the subsurface water level etc.) while the climate is dry. We assume that it was at least not too humid during the greatest change in sea-level. This assumption is also only based on the other assumption that the sand-dunes covering the Western Desert are not only derived from dry-land-disintegration of pre-existing clastic sediments but from off-shore stretches, laid bare by the receding sea also. Moving sand-dunes of such a scale require at least a semi arid climate.

Huzayyin (1941) also throws a weighty argument into the discussion when he says that the post-pliocene time was rather short for the tremendous excavation actually performed. We are aware that this may be applied against our thesis as well, since river-scouring may be even quicker than our chemico-aeolian excavation. But we mentioned on page 182 already that the first steps in the formation of the Fayoum depression might be attributed to a drainage-system created after the structure of the Delta region and the creation of a «powerful» near-by baselevel in miocene times. This comparatively local drainage system was later on put out of action *a*) by diminishing rainfall in Pliocene times (compare page 184-185) *b*) by the rapid incision of the Nile proper, which previously followed a more south-westerly course (compare Pfannenstiel, 1952).

We therefore suggest that the Oasis depressions were formed by chemical weathering at places, where subsurface water could reach the surface during dry periods and thus act as strongly decaying agents.

Such places were determined by structural developments in the broadest sense of the word (warps, faults-zones, folds). The overdeepening depends on a varying and changing « head » of the artesian water, resp. on varying other subsurface water levels owing to either very dry periods or—more probably—during eustatic sea-levels minima (Pfannenstiel, 1944, and later papers Zeuner, 1950; Huzayyin, 1941; Ball, 1939). That means probably—as anticipated for the Fayoum by Sandford and Arkell (1929) in post pliocene times. Beadnell finds its origin in pre-pleistocene times. Huzayyin tends to support Beadnell but possibly the age of the depressions is different. So, as geochemical developments within certain regions may produce « metallogenetic provinces » displaying a remarkable likness of ore deposits through ages, so we might just as well expand the idea of a geochemical province to the external « agencies » producing type-land-scapes.

It remains therefore to be investigated, whether the southern Oases are formed earlier than the northern ones. There seems to be an indication in the age-relation of calcareous tufas to palaeolithic cultures as mentioned in Ball (1939) (compare Zeuner, 1941 reviewing Gardner and Caton Thompson). Furthermore Huzayyin (1941) indicates similar features pointing towards the origin of the southern Oases prior to the Northern ones.

That might mean that Kharga Oasis was excavated before late-Pliocene times. Huzayyin does not record the climates before Uper Pliocene but we gather that we had at least dry spells in Middle-Pliocene times.

VI. SUMMARY AND CONCLUSIONS

Two questions were asked in the introduction of this work (page 154). The *first* concerned the evolution of a great river within its structural frame.

It may be answered that the Nile Basin is tectonically analogous to the « High African » Basins, bordered by mainly N.-W. and N.-E. trending swells. The Basin may also be compared with the Western basins of the Indian Ocean showing a « flowing » or sigmoidal distortion. It may thus indicate its more « deep »—than « high » cratonic position (Stille, 1935). Its formation took place just outside the « African Shield proper » and in its geological shelf portions. The basin-system existed without doubt before the Nile existed but it was slowly deformed and is still being deformed.

The cataract-portions are indications of warping movements parallel to the ancient D-structures. The river could not always cope with the warping and was sometimes in its history blocked for a while.

The *second* question was, whether the minor structural features of the two lower Nile basins consisting of thick alternating competent and incompetent beds, indicate a general law of distortion or not.

They were found to correspond to major structures. Their analysis was undertaken by the evaluation of tributary dry-rivers (wadis) following structural lines.

It was furthermore suspected, that the Nile did flow prior to Pliocene in a course between the Fayoum and Baharyia and only gained its present lower course in latest Miocene or in early Pliocene times, when the tectonic Delta-Triangle became definitely dry land. It is assumed that a local drainage system in the direct hinterland of the Delta captured the lower Nile in this time.

A structural survey of the Western Desert and the structural position of the Oasis-Depressions led to some considerations concerning their origin which was hypothetically explained by intensive chemical weathering in places where structures permit the subterraneous water to come within reach of evaporation creating an immense accumulation of brackish solutions, which destroyed the country rock. The decomposed material was exported by wind.

No proper wind-blast-corrasion is assumed.

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THE CLIMATE OF THE BRITISH ISLES

A NEW CLASSIFICATION

BASED ON ACCUMULATED TEMPERATURE, DURATION OF GROWING SEASON AND PRECIPITATION EFFECTIVENESS

BY

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In the present age, when all branches of science and knowledge are closely interrelated, climatology has been faced with rapidly increasing responsibilities toward many varied sciences such as agriculture, industry, botany, hydrology and town planning. A writer in such subjects often finds it necessary to devote a chapter or at least a section of a chapter in the first part of his work to the study of the main climatic features of the region under consideration. In many cases, however, a reader may fail to recognise the relation between such features and other separately discussed phenomena. This is particularly due to the fact that climatology has been, traditionally, treated as an independent science and hence its strong relation with other sciences has not been sufficiently pointed out. But the time has come for climatologists to strengthen their co-operation with other investigators and offer them climatic information in forms that can meet their various requirements.

Since weather observations began to be systematically recorded at the beginning of the XIXth century, geographers have been adopting an almost unchanged method in studying the climatic elements. In the case of temperature, for instance, monthly and annual means are plotted on maps, and places having the same means are connected by isotherms. For drawing such isotherms, the effect of altitude must be eliminated

by correcting the recorded values so as to represent conditions at sea level; the rate is approximately 1° F. for each 280 feet. This method, although of value for general studies and comparisons on a continental scale, is not of great help either for a detailed climatic investigation in its proper sense or for other investigations seeking application for practical purposes, especially within small regions. What is required is not a set of maps with pages of explanation on what temperature conditions would be if one could imagine that a whole country was absolutely flat and at sea level. What is really needed is a realistic representation of what actually exists and is already acting on the physical and biological composition of the earth.

Here attention must be drawn to the real effectiveness of the various climatic elements, rather than to their recorded values. Several attempts have already been made in different countries to determine the effectiveness of temperature and precipitation. Although an increasingly large number of formulae and indices have been devised, no one is sufficiently supported by evidence in nature.

In the following pages an attempt is made to examine some of the latest approaches to the study of regional climatology, and to show how far they may be utilised in one particular region, namely the British Isles.

TEMPERATURE EFFICIENCY

Although there is a general agreement upon the profound influence of temperature conditions on plant distribution, the fundamental problem of determining the real effectiveness of different temperatures on different plants at their different stages of life is still far from being agreed upon. Almost all climatic classifications suggested so far by writers in various countries are based on temperature values in their ordinary thermometric terms, although it is generally admitted that such values are not always indicative of the real effect of temperature on plant life.

In 1913 Livingstone (1) wrote : « What appears to be requisite in this general connection is some kind of temperature indices, which shall express the temperature values in terms of the possible effectiveness of

the observed temperature.» Livingstone suggested three forms of temperature effectiveness indices : they may be «exponential», «physiological» or «remainder». The first two forms, although they have recently been used by some climatologists such as Thornthwaite (1948), are of more interest to botanists and ecologists than to geographers; so they will be mentioned here only very briefly, while more attention will be paid to the third form.

EXPONENTIAL AND PHYSIOLOGICAL INDICES

For exponential indices one must take into account the fact that the physiological processes of plant metabolism are generally chemical and physical reactions. These reactions follow in most cases the well known law of Van't Hoff (3), according to which the growth rate of plants approximately doubles with each increase of 18° F (10° C) in the mean temperature, but begins to slow down after reaching an optimum which varies considerably from one plant to another. Van't Hoff states that plants usually begin to function at a unit rate when the daily mean temperature is about 40°, and hence each rise of 18° F over this threshold doubles the rate, making it 2 at 58° F, 4 at 76° F and so on. So the efficiency of different temperatures might be calculated as follows : $Te = 2^{\frac{t-40}{18}}$; where (Te) is the temperature efficiency and (t) the mean daily temperature.

For physiological indices, on the other hand, the effectiveness of different temperatures on a plant's growth at its different stages is determined experimentally, so as to find out the optimum temperature at which the growth rate is most rapid. In 1914 Lehenbauer (4) found, for instance, that the best growth of maize seedlings occurred when the temperature was between 84° and 90° F. In 1936 Wadley (5) found that the rate of development of green bug was greatest when the temperature was 86° F. Weaver and Clement (6) also stated that the most rapid growth of wheat takes place at a temperature of about 88° F; they also stated that all experiments so far carried out show generally that optimum temperatures for the growth of most temperate plants lie between 61° and 90° F, while temperatures exceeding 90° F may be most favourable for the growth of tropical plants.

It must be noted, however, that the results of such laboratory experiments are unfortunately of little help in the study of plants in their natural environment. In nature, for instance, any one temperature is not long maintained as it sometimes may be during an experiment. Moreover, temperature constitutes only one of many factors affecting the life of plants in various ways. Thus the few results reached by laboratory experiments on particular plants must not be given the status of general rules; and great care should be taken when applying such results to other plants or even to the same plant under natural conditions.

ACCUMULATED TEMPERATURE

The third form of indices, *i.e.* the «remainder indices», is based on the addition of heat units (or temperature degrees) available during the growing season, above the minimum mean temperature required for the start of plant growth. These units are generally termed «accumulated temperature.» This method of estimating the effectiveness of temperature is more suitable for the study of climatology than the methods based on laboratory experiments, for various reasons. Firstly, it is simple and may be easily applied in both general and detailed regional climatic studies, especially if it is noticed that all the data required for its application are the mean daily temperatures which are often available; secondly, it reveals the influence of temperature on plants in their natural environments; thirdly, it makes use of the well established principle that the growth and general appearance of plants are determined by the amount of heat units accumulated during the life of the plant, rather than by the variable daily means (2).

It must be noted, however, that plants vary considerably with regard to the amounts of temperature units required for their growth and maturity. Many field experiments have been carried out in some countries of Europe and America, but most of such experiments have so far been concerned with the growth of wheat. At Rothamstead (England) experiments showed that wheat required about 1960° F. (1100° C.) accumulated above the daily mean of 42° F., during its life (between germination and ripening) (7). Some wheat varieties, however, have been

produced for cultivation in more northern latitudes, viz. in northern Canada and Russia. The long duration of daylight in such latitudes helps to accelerate plant growth, and hence smaller amounts of accumulated temperature may be needed. Some varieties of wheat grow successfully in regions where the total accumulated temperature (over 42° F.) does not exceed 750° C. as in Alaska.

The lowest mean temperature at which plants begin to function varies also from one plant to another. This minimum temperature is usually termed « the zero point of growth». According to Kincer, this point may be 37° F. for spring wheat, 43° F. for oats, 55° F. for corn and 62° F. for cotton (8). The accumulated temperature is generally taken as the excess of temperature above the zero point of growth.

For general climatic and botanical studies a number of approximate zero points have been suggested. The mean temperature of 43° F. has been recognised by some authorities as the minimum temperature at which most plants of the temperate latitudes begin their growth; see Köppen (9), Austin Miller (10), Blair (11) and the U. S. Department of Agriculture's « Climate and Man» (8).

The mean temperature of 42° F. has been recently used by the Meteorological Office (London) as a basal limit for estimating the amounts of accumulated temperature. It will be also used here in our study of the duration of the growing season and accumulated temperature in the British Isles.

Calculation of Accumulated Temperature. The accumulated temperature may be calculated for a day, a week, a month or any other period. It may also be calculated above or below the zero point of growth.

The Meteorological Office (London) recommends the calculation of accumulated temperature of single days by using certain formulae based on the maximum, minimum and mean temperature (12). To avoid unnecessary repetition of calculations, estimates of accumulated temperature (above and below 42° F.) for combinations of various maxima and minima have been set out in tables.

For climatic studies such a method is unfortunately of little help. To estimate the accumulated temperature of a month, one has to calculate the degrees accumulated in each single day of the month. Obviously,

therefore, the prospect of calculating monthly and annual averages is discouraging, to say the least. It may be preferable, at present, to determine the accumulated temperature of a month simply as the excess or deficiency of the month's mean temperature above or below 42° F. This simple method is allowed by the Meteorological Office only if both the daily maxima and minima of all the days of a month are either above or below 42° F. For the months during which both the daily minima and maxima fluctuate around this criterion the accumulated temperature must be estimated for each single day; fortunately, such months do not contribute much to the annual total of accumulated temperature in the British Isles above the zero point of growth (42° F.). Hence, we may state that the uncertain validity of our simple method is of very minor importance.

In fact, the accuracy claimed by the Meteorological Office is quite debatable; there is, for instance, a striking discontinuity in the variation of the results given in the tables, with varying temperatures, especially when the daily mean temperatures are in the neighbourhood of 42° F.: this is clear in table I.

TABLE I. *A section of the Meteorological Office tables for calculating accumulated temperature above 42° F. « A».*

MINIMUM TEMPERATURE	MAXIMUM TEMPERATURE							
	50	49	48	47	46	45	44	43
41	4	3	3	2	2	1	1	0
40	3	3	3	2	1	1	1	0
39	3	3	2	2	1	1	1	0
38	3	3	2	1	1	1	1	0
37	3	2	2	1	1	1	1	0
36	3	2	1	1	1	1	1	0
35 to 20	2	2	1	1	1	1	1	0

Also, with regard to the accumulation of temperature *below* 42° F., the tables give sometimes very curious results; *e. g.* a day for which the maximum and minimum temperatures are 43° and 39° has a deficiency of one degree below 42°; which is the same amount given to a day with a maximum of 75° and a minimum of 40°.

ACCUMULATED TEMPERATURE AND THE GROWING SEASON OVER THE BRITISH ISLES

Temperature conditions in the British Isles will be shown here in a new picture which, though having the same background as the old familiar one, may be more closely matched with the pictures of other phenomena, the distribution of which is affected by the distribution of temperature on a large scale.

The most important elements of the new picture are :

1. The duration of the growing season;
2. The accumulated temperature above 42° during the growing season.

Attention must first be drawn to the definition of the term « growing season». An agriculturalist or a farmer talks about the « growing season» when he means the interval between sowing and harvesting of crops; such an interval varies considerably with the kind of plant and with soil and moisture conditions. A climatologist, on the other hand, defines the growing season in temperate and cold regions as the entire period of the year during which the mean temperature does not fall below the « zero point of growth» for most plants [1].

In the British Isles almost all climatic data are for stations of comparatively low altitudes, usually below 1,000 feet. Thus one must note to correct the result if higher altitudes are considered. This remark is of the utmost importance in the British Isles where topographical features

[1] In American publications, however, the growing season is often defined as the average interval in days between the last « killing frost» in spring and the first in autumn. This definition affords a satisfactory measure for the less hardy crops in warm regions, such as for maize, but in cooler climates the duration of the mean temperature above 42° F may be more significant for determining the growing season.

vary greatly. In the following discussion we shall be concerned mainly with altitudes not exceeding 1,000 feet unless particular altitudes are stated.

The map of fig. 1 shows the duration of the growing season in the British Isles. Clearly, the duration of the growing season, just as temperature, is controlled by altitude, latitude and proximity to the sea.

The altitudinal shortening of the season may be determined on the basis of the temperature lapse rate. In 1945 Manley suggested a reduction of ten days in the duration of the growing season on the Pennines for each 260 feet (13).

Comparing the mean temperature at the top of Ben Nevis with that of Fort William (table II *b*) it has been found that the temperature lapse rate of the months (April-November) during which the mean temperature is usually over 42° F., is 1° F. for each 271 feet. By interpolation it has also been found that a reduction of 1° F. in the average temperatures of Fort William entails a decrease of 16 days in the length of the growing season; *i. e.* a shortening of 16 days with each 271 feet of increase in height.

In the warm southerly parts of Britain the shortening of the growing season with elevation is normally more rapid than in the north. Unfortunately, it has not been possible to find data for proper comparisons, but one may form a fairly good idea if the figures of Princetown (1430 ft.) are compared with those of the nearest station of Newton Abbot (375 ft.)-(table II *a*); this has shown that the duration of the growing season decreases 10 days for each 96 feet.

The intensity of warmth is generally determined by the amount of accumulated temperature of the growing season rather than by its duration; a region where 3,000 F° accumulate in three months is definitely very hot in comparison with another where 4,000 F° accumulate in six months. In London, for instance, accumulated temperature of the growing season (265 days) is over 3,200 F°, whereas along the western coasts of Wales the total amount of the whole year often does not exceed 3,000 F°.

Fig. 2 shows the distribution of accumulated temperature above 42° in the British Isles.

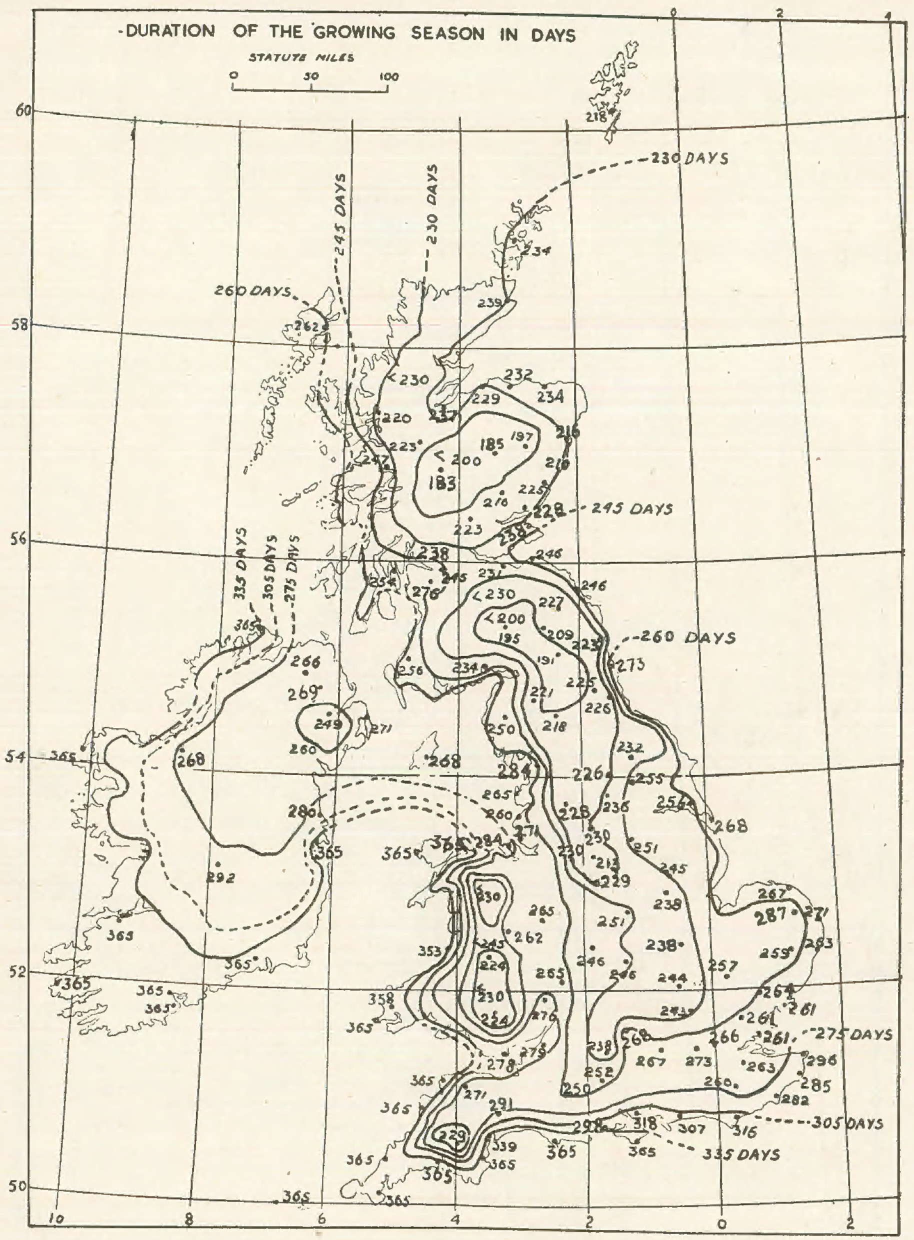

Fig. 1.

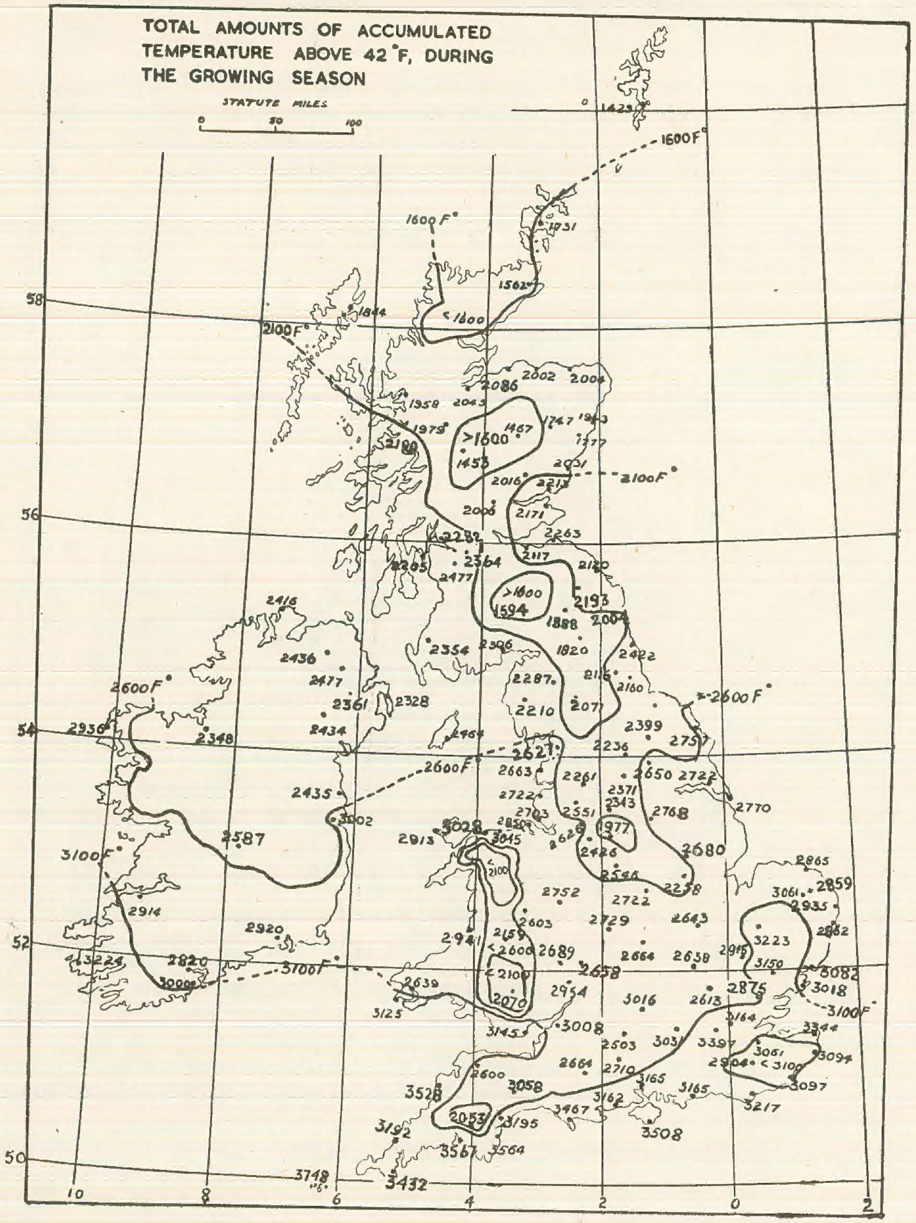

Fig. 2.

Table II. *Mean monthly temperature at two pairs of adjacent stations of different height* (°F.).

	(a)		(b)	
	Princetown (1,430 ft)	Newton Abbott (375 ft)	** Ben Nevis (4,406 ft)	Fort William (171 ft)
	DEVON		INVERNESS	
	1906-20 and 1929-35	1925-35	1884-1903	1881-1915
January	37.5	42.0	23.4	38.9
February	37.0	41.5	24.1	38.8
March	39.0	44.0	24.3	40.6
April	43.0	47.0	28.3	44.8
May	49.5	52.5	33.2	50.1
June	54.0	58.5	40.0	55.6
July	56.5	62.5	41.7	57.2
August	57.0	61.5	40.8	56.6
September	53.5	58.0	38.0	53.5
October	47.5	52.0	31.4	47.5
November	41.5	45.5	29.4	42.9
December	39.5	42.0	25.7	39.7
Average	46.0	50.5	31.7	47.2

N.B. Allowance must be given to the differences of the periods of observation
** See ref. (4).

Over the country as a whole, July and August are the warmest months of the year. Their contribution to the accumulated temperature of the season is about half the total amount; though it may be somewhat less than that in the extreme south and south west where the growing season lasts all the year round.

Fig. 3 shows that the general trend of July isopleths is more or less between east and west, with some remarkable bends southward round the mountain systems; this is particularly clear with regard to the 500 and 550 isopleths.

Unlike the isopleths of July, those of January (fig. 4) run generally between north and south. This is due to the overwhelming marine influence as compared with the influence of other factors. It is worth noting

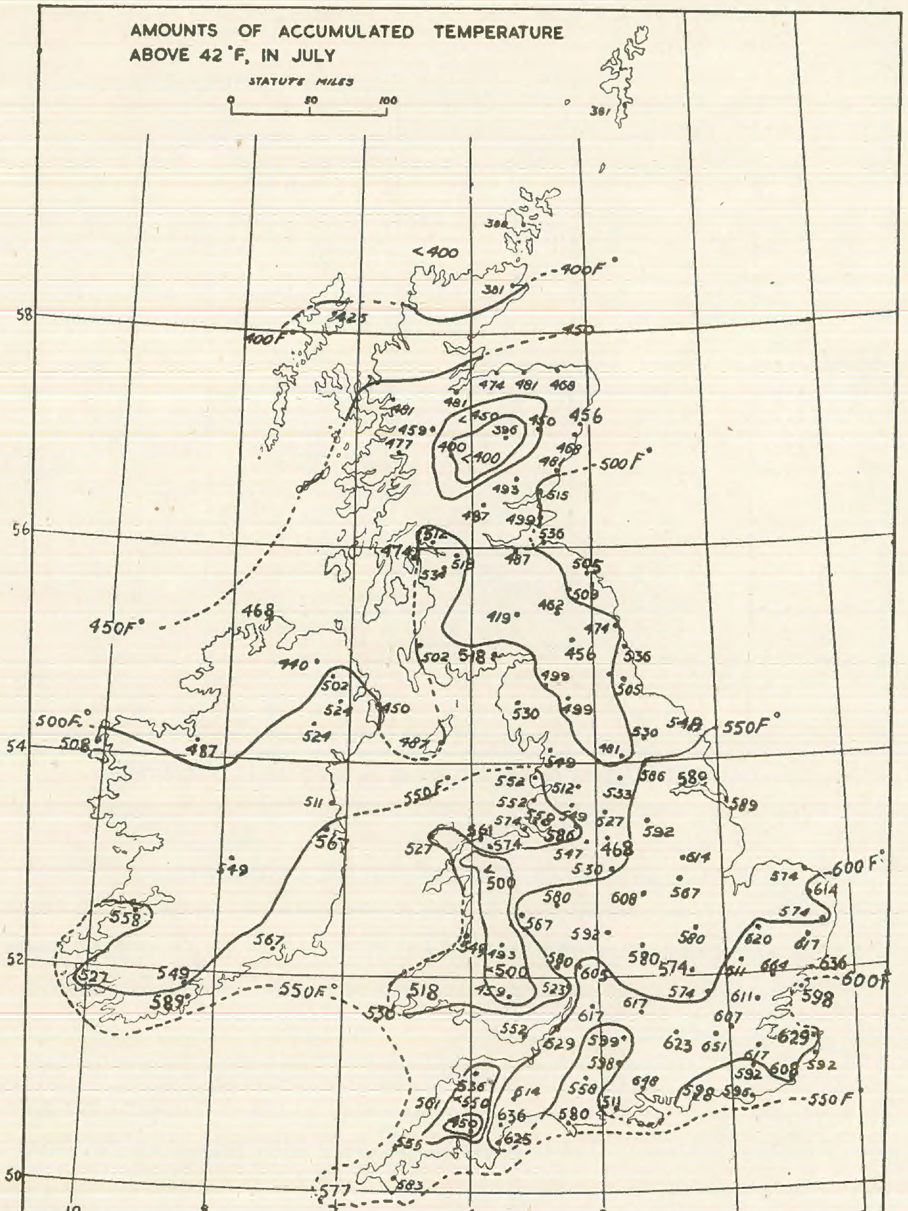
AMOUNTS OF ACCUMULATED TEMPERATURE
ABOVE 42°F. IN JULY
STATUTE MILES
0 50 100

Fig. 3.

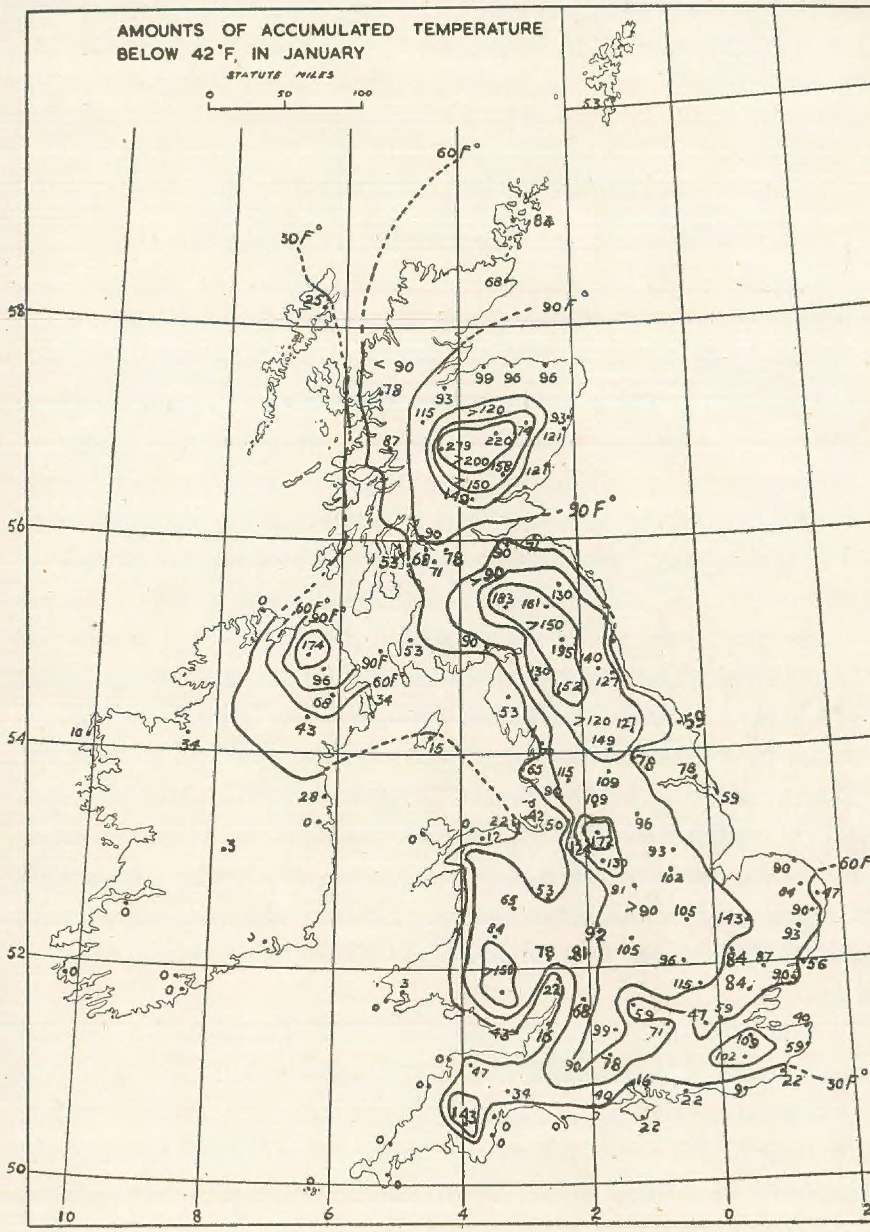
AMOUNTS OF ACCUMULATED TEMPERATURE
BELOW 42°F. IN JANUARY
STATUTE MILES
0 50 100

Fig. 4.

that the Midlands and East Anglia are among the coldest regions of the country in winter; they are generally colder than most of the coastal areas, including the northern islands.

PRECIPITATION EFFECTIVENESS

Evaporation and Transpiration, «Evaspiration»

With temperature, precipitation is the most influential controller of life on land. Not all precipitation, however, is exploited by plants, animals and man; great amounts are usually lost through evaporation from soil and water surfaces or transpiration from plants. The estimation of such amounts has become one of the main themes of modern climatology.

Several lines of approach have been followed to determine evaporation and transpiration. Evaporimeters are installed at a limited number of sites, but the results obtained are neither reliable nor useful for comparison, because of the striking differences in the design of the gauges and the conditions under which they are installed. In such measurements it is practically impossible to take into account all the factors affecting evaporation from natural water or soil surfaces.

The measurement of transpiration is more recent than that of evaporation. Very few laboratory experiments have been carried out on particular plants, but as is the case in evaporation, the results obtained do not represented conditions in nature. The rate of transpiration varies considerably with the type of plant and the environment in which it grows.

To avoid the numerous difficulties and defects of such instrumental measurements of evaporation and transpiration most writers prefer to determine the water loss as a function of other atmospheric elements controlling it. No one of the methods suggested is, however, supported by evidence in nature. Moreover, the data required for the application of some methods are often not available.

To meet the needs of climatologists, agriculturalists, hydrologists and others, a simple combined determination of both evaporation and transpiration has been recommended. This is supported by the fact that the two phenomena are generally controlled by the same factors. The term «evapotranspiration» is used by Thornthwaite to mean the total loss of water through evaporation and transpiration (15). Other writers such as Penman refer to it merely as evaporation (17, 18). Water engineers often use the terms «total loss» or «total evaporation». For the sake of convenience and simplicity the term «EVASPIRATION» will be used henceforth to signify combined evaporation and transpiration.

Methods of Estimating «Evaspiration». Among all methods devised to estimate evaspiration two at least may be promising; these are Thornthwaite's method, 1948 (15) and Penman's method, 1950 (14). But both methods, especially the latter, are unfortunately so complicated that geographers are often discouraged to exploit either of them.

In his method, Thornthwaite distinguishes between the amount of water which actually evaspirates and that which may do so if it were available. The latter, which may be termed «potential evaspiration», is defined also as the loss of water from a surface covered with a plant sheet. But although transpiration differs considerably from one plant to another, Thornthwaite does not give this fact enough consideration in not stating which type of plant is assumed, and thus many of his conclusions lose a great deal of their significance. Also, this method loses most of its merit through the long and laborious process of computation; this process may be summarized in the following order :

1) The heat index (of the station) is determined for each month as

$$i = \left(\frac{t}{5}\right)^{1.514};$$

i = the heat index of a month;

t = the month's temperature (degrees Centigrade).

Values of «i» for various temperatures are given in a special table.

2) The heat index of the whole year «I» is the sum of the «i» values of the twelve months.

3) A curve has to be drawn on a logarithmic paper to express the relation between the mean temperature on the one hand and the potential evaspiration (in centimetres) on the other. All curves expressing such a relation tend to converge at one point, viz. where temperature reads 26.5° C. and potential evaspiration 13.5 centimetres; provided that the mean monthly temperature does not exceed 26.5° C. The slope of the curve is fixed by the heat index « I » of the station as shown on a special scale.

4) Since the drawn curve represents the correlation between temperature and evaspiration, the values of the latter can be read on the nomogram for various temperatures.

5) The values obtained must then be adjusted for a standard month of 30 days with 12 hours of sunlight in each day. Thornthwaite suggests certain factors which vary with the month and latitude.

The method is based on the fact that there is a high correlation between temperature and evaspiration. Such a correlation has been proved by Thornthwaite and others to be almost linear, but instead of exploiting this fact to provide an easy course for estimating evaspiration, Thornthwaite has become involved unnecessarily in a tortuous procedure to obtain his results.

At 144 stations, well distributed over the British Isles, I have noticed that a linear correlation is apparent between the unadjusted estimates of potential evaspiration as determined by Thornthwaite's method on the one hand and the monthly mean temperatures on the other. The correlation can be expressed numerically as follows :

$$E\ (\text{cm.}) = \frac{T(°F)-a}{3.4} \quad \text{or} \quad E\ (\text{in}) = \frac{T(°F)-a}{8.64}$$

If degrees Centigrade are used the formula becomes :

$$E\ (\text{cm.}) = \frac{T(°C)-\acute{a}}{1.9}$$

In all formulae, E is the unadjusted potential evaspiration (of a month), T is the mean monthly temperature and *a* or *á* is a factor which

increases with any increase in the mean temperature. At Eskdalemuir (Scotland), for instance, where the annual mean temperature is 44.3° F. (6.9° C.) the factors *a* and *á* must be 29.9 and -1.16 respectively. At Scilly the mean annual temperature is 52° F. and here the factors *a* and *á* must be 35.2 and 1.72 respectively. The factors which may be used for the British stations the temperature of which ranges between 43° and 52° F., are given in table III.

TABLE III. *Values of the Correction Factors « a » and « á »*

Annual mean temperature		The values of the factors	
°F	°C	*a*	*á*
43	6.1	29.1	– 1.73
44	6.6	29.7	– 1.35
45	7.2	30.4	– 0.97
46	7.7	31.1	– 0.59
47	8.3	31.8	– 0.21
48	8.8	32.5	0.17
49	9.4	33.1	0.55
50	10.0	33.8	0.93
51	10.5	34.5	1.31
52	11.1	35.2	1.69

It may be interesting to note that the values of *a* and *á* have given results accurate enough to make it necessary to take into account the fractions which may occur in the annual means of temperature. For an annual mean of 43.5° F., the estimate of potential evaspiration should be more accurate if « *a* » is taken as 29.4, which is about half way between the values corresponding to the means of 43 and 44° F.

Since the formula gives only unadjusted values of potential evaspiration, these must be adjusted for a standard month of 30 days, with 12 hours of sunlight in each day. This may be done in the same way as Thornthwaite suggests.

The modified method outlined above is accomplished by means of a nomogram (fig. 5) which can be used to assess monthly evaspiration (unadjusted) at any station in the British Isles.

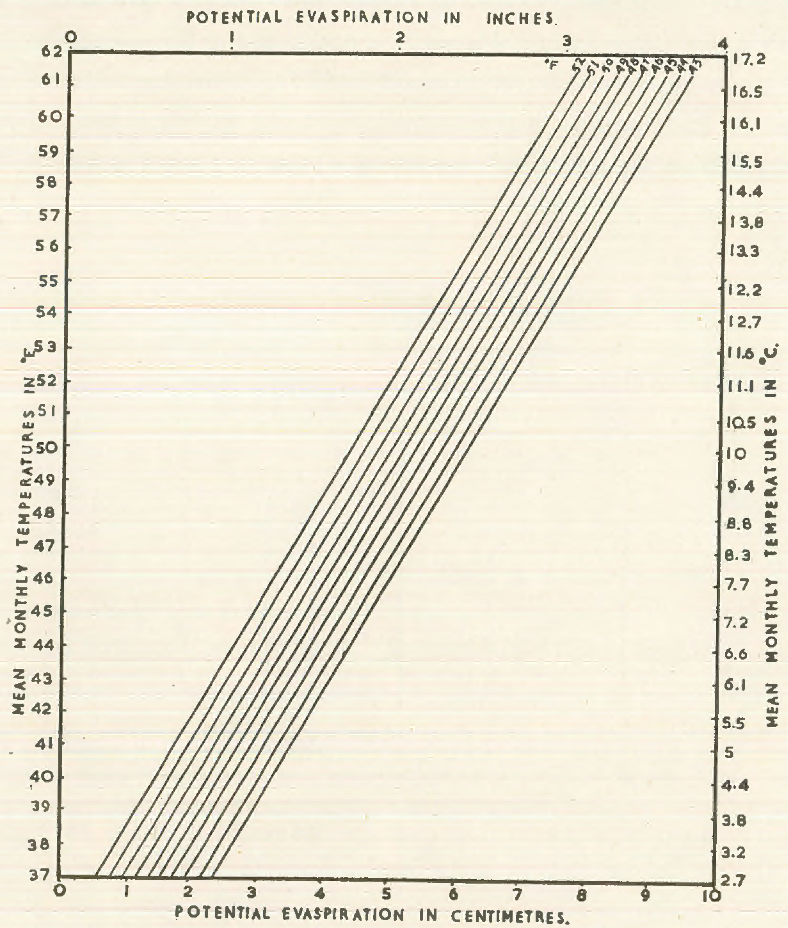

Fig. 5. A Nomogram for Determining Unadjusted Values of Monthly Evaspiration at Stations with Mean Annual Temperatures Ranging from 43° to 52° F. (Each Line Must be Used Only for Stations with Annual Mean Temperature Corresponding with the Degree Written Against it).

In table IV are given the values of evaspiration as determined, firstly by Thornthwaite's method of computation and secondly by our modified method. It is clear that the differences between the results given by the two methods are negligible. In fact the sources of error in Thornthwaite's process of computation are considerable, either in reading the heat indices in the tables, where many approximations must be made, or in the logarithmic representation. More errors may occur if the temperature degrees are converted to Fahrenheit from Centigrade, or vice versa. Each of such sources of error may not be important if considered individually, but may result in inaccuracies ranging from 0.1 to 0.7 centimetres when they are combined.

Fig. 6 shows the distribution of evaspiration over the British Isles as determined by the modified method.

DETERMINATION OF PRECIPITATION EFFECTIVENESS

It is clear that the effectiveness of precipitation is generally controlled by the loss of water through evaspiration; this factor, however, is still far from being satisfactorily determined, as shown in the foregoing discussion. Several formulae have been published for estimating precipitation effectiveness. According to such formulae the effectiveness of precipitation may be estimated as a function of one of the following groups of elements.

a) Temperature and precipitation;

b) Saturation vapour pressure, relative humidity and saturation deficit;

c) Evaporation or evaspiration.

Among the formulae which have provoked the interest of writers in various countries are those devised by Köppen, 1928 (9), de Martonne, 1926 (19, 20), Meyer, 1926 (21) and Thornthwaite, 1931 (16) and 1948 (15); the first three in particular have been widely used and often quoted in text books.

Table V shows the limits of the major types of vegetation as expressed by certain writers, on the basis of the effectiveness of precipitation. With the exception of Thorthwaite's latest criteria, all other limits are determined as functions of precipitation and mean temperature.

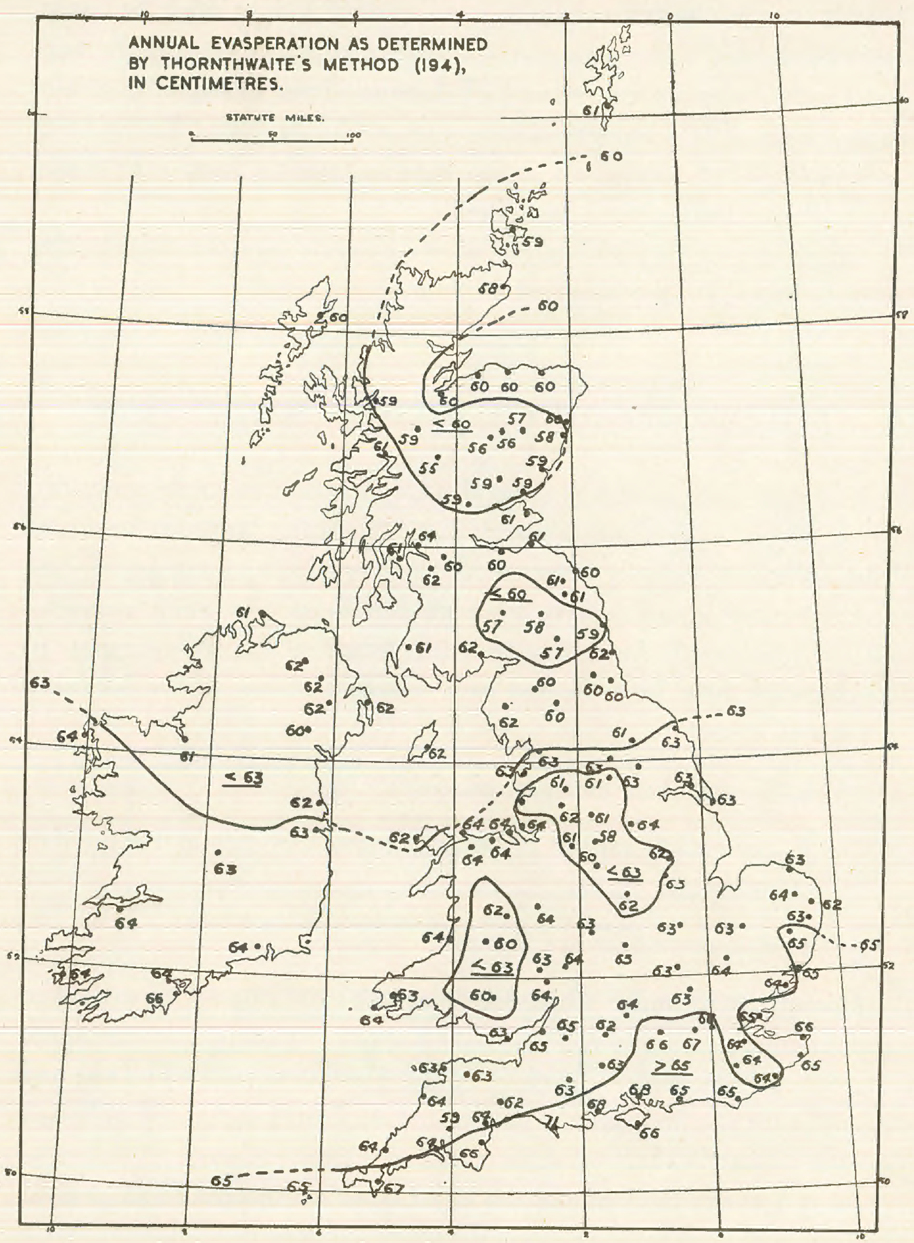

Fig. 6.

TABLE IV. *Unadjusted values of potential evaspiration as obtained by Thornthwaite's method and by formula (centimetres)*

Month	HARROGATE				DUBLIN			
	T° F	Th's method		$E=\frac{T-31.8}{3.4}$	T° F	Th's method		$E=\frac{T-33.8}{3.4}$
		i	Pot. Ev.			i	Pot. Ev.	
January	37.2	0.43	1.60	1.59	43.0	1.36	2.77	2.70
February	37.9	0.52	1.80	1.80	42.9	1.33	2.74	2.68
March	39.5	0.76	2.30	2.27	44.0	1.54	3.02	3.00
April	44.0	1.54	3.60	3.60	46.7	2.10	3.80	3.77
May	50.9	3.08	5.60	5.61	52.3	3.42	5.40	5.44
June	55.0	4.14	6.75	6.82	56.9	4.67	6.80	6.80
July	57.5	4.84	7.52	7.56	60.3	5.68	7.77	7.79
August	58.0	4.98	7.64	7.70	59.8	5.51	7.63	7.64
September	53.7	3.78	6.40	6.44	56.1	4.43	6.54	6.56
October	47.9	2.37	4.75	4.73	51.1	3.13	5.10	5.14
November	41.5	1.07	2.86	2.82	75.5	1.85	3.50	3.44
December	38.5	0.62	1.96	1.94	43.5	1.44	2.93	2.85
Year	46.9	28.13 (I)			50.1	36.46 (I)		

Month	ESKDAIEMUIR				SCILLY			
	T° C	Th's method		$E=\frac{T-(-1.16)}{1.9}$	T° C	Th's method		$E=\frac{T-1.72}{1.9}$
		i	Pot. Ev.			i	Pot. Ev.	
January	2.25	0.30	1.69	1.79	8.1	2.10	3.40	3.36
February	2.25	0.30	1.69	1.79	7.5	1.85	3.10	3.04
March	3.1	0.50	2.22	2.24	8.1	2.09	3.45	3.36
April	5.0	1.01	3.29	3.24	9.0	2.46	3.86	3.83
May	8.4	2.23	5.12	5.25	11.2	3.42	5.00	4.99
June	11.1	3.35	6.46	6.45	13.9	4.72	6.41	6.41
July	13.0	4.26	7.42	7.45	15.8	5.75	7.40	7.41
August	12.5	4.00	7.20	7.18	15.8	5.73	7.40	7.41
September	10.0	2.86	5.88	5.87	14.7	5.14	6.83	6.83
October	7.0	1.67	4.34	4.30	12.2	3.90	5.55	5.52
November	3.75	0.64	2.57	2.58	9.5	2.66	4.12	4.10
December	2.7	0.40	1.96	2.03	8.4	2.21	3.55	3.52
Year	6.9	21.52 (I)			11.25	42.03 (I)		

See the nomogram of Fig. 7.

N.B. For the first two stations degrees Fahrenheit are used; for the second two, degrees Centigrade.

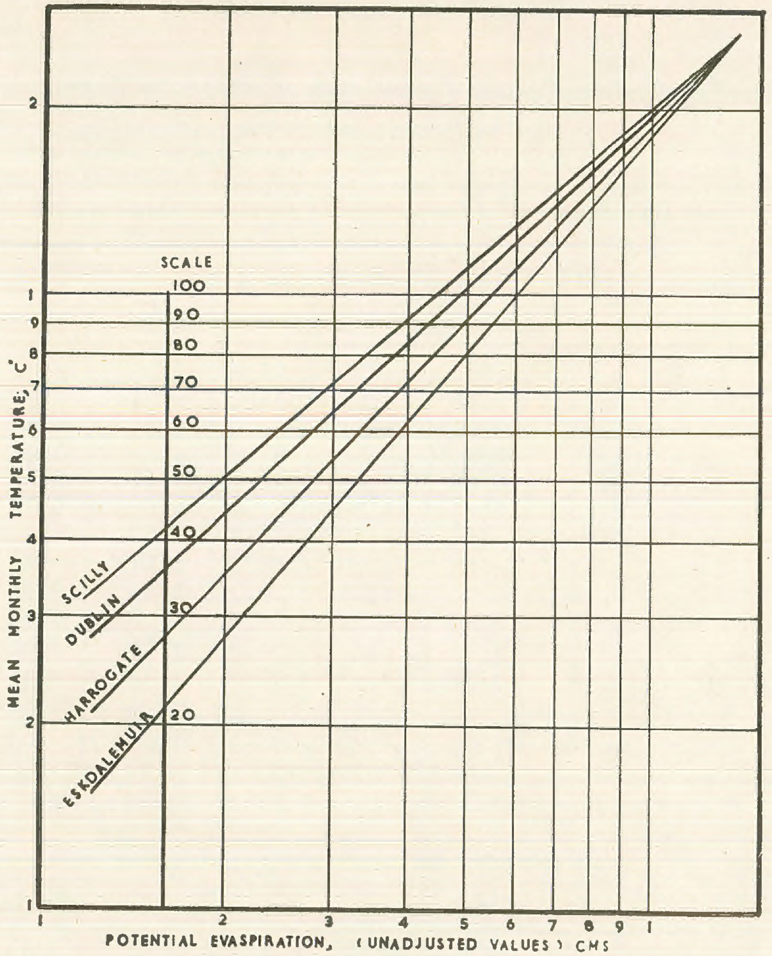

Fig. 7. A Logarithmic Nomogram for the Determination of Potential Evaspiration at Certain Stations.

TABLE V. *Climatic Boundaries according to certain writers (annual values)*

Climatic type	Characteristic vegetation	Köppen 1923 P/T + 7	de Martonne 1926 P/T + 10	Thornthwaite 1931 $\sum_{n=1}^{12} 1.65\left(\frac{P}{T+12.2}\right)^{\frac{10}{9}}$	Thornthwaite 1948 $\frac{100s-60d}{n}$	Setzer 1946 $\sum_{n=1}^{12} P/1.07^t$
Wet	Rain forest					
		40	40	128	100	520
Humid	Forest					
		30	30	64	20	260
Sub humid	Grassland					
		20	20	32	— 20	130
Semi arid	Steppe					
		10	10	16	— 40	65
Arid	Desert					

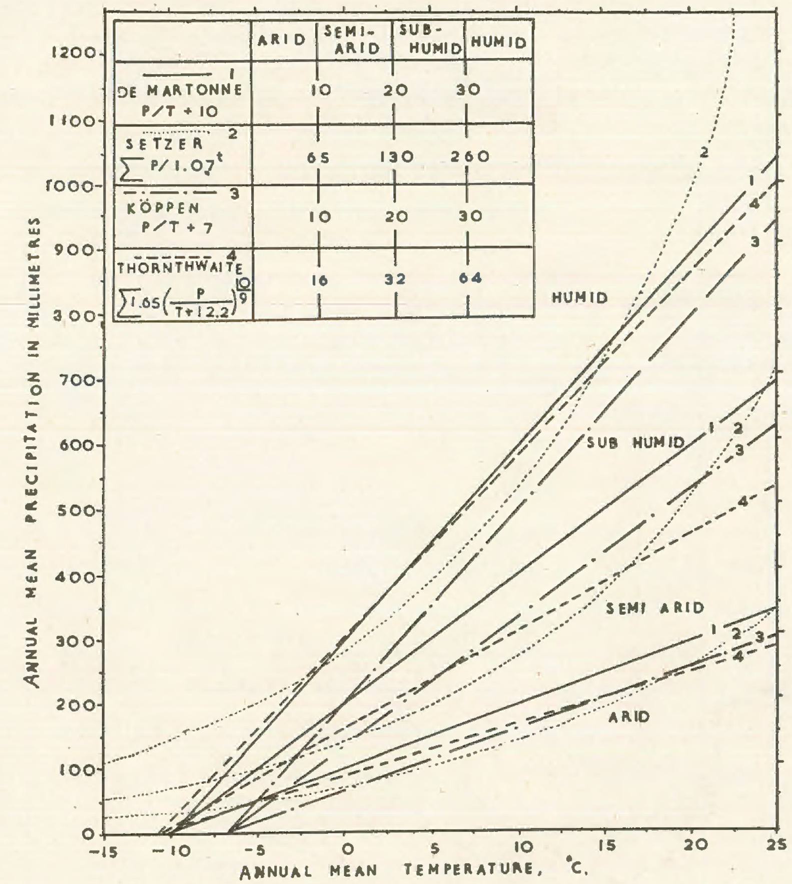

Fig. 8. Climatic Boundaries According to Certain Formulae.

The various boundaries are shown graphically in fig. 8 [1]. The arrangement of the curves suggests that a profitable modification is possible if the differences among all of these curves could be reduced to the

[1] To be comparable with de Martonne's and Köppen's formulae those of Thornthwaite (1931) and Setzer are assumed to be applicable on a yearly instead of a monthly basis, *i. e.* to use annual mean temperature and precipitation instead of the monthly averages. In fact, I have found after application to the British Isles that the differences between results obtained in both ways are not appreciable.

minimum. Thus the mean boundaries shown in fig. 9 may be worth consideration.

The suggested mean boundaries may be interpreted in terms of precipitation effectiveness by the formula $E = \frac{P}{T+9}$; (E = the precipitation

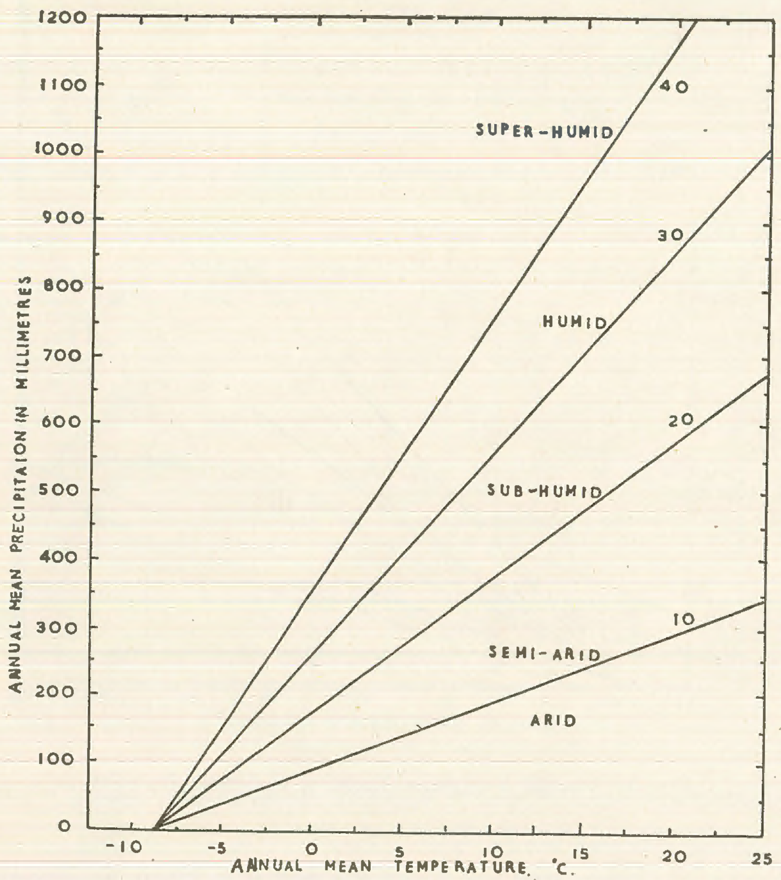

Fig. 9. Climatic Boundaries According to the Mean Function $\frac{P}{T+9}$.

effectiveness, P = the annual precipitation in millimetres and T = the mean annual temperature, Centigrade).

The formula may also be applied to individual months, in which case the monthly values of precipitation and temperature must be used and the results must be multiplied by 12 to be comparable with the annual values.

The formulae given in table V, as well as the « mean function of Humidity $\frac{P}{T+9}$» have been applied to the British Isles. Precipitation effectiveness of 140 stations is determined by each of the six formulae and six maps are drawn; only two of these maps are shown in figs. 10 and 11. All maps show almost the same order of magnitude as indicated by the general trend of isopleths. This further illustrates the close correlation between the various formulae.

Table VI shows the boundaries of different moisture divisions as fixed by the « Mean function of humidity» and the corresponding limiting values set by the other formulae. These boundaries are based on the results obtained for the British Isles; but due to the absence of arid or semi-arid climates in the British Isles, boundaries of these types are fixed arbitrarily in proportion to the boundaries of the other more humid types, and hence may be adjusted if necessary.

It is particularly interesting to notice a strikingly high correlation between the distribution of Thornthwaite's « moisture index» and the distribution of the precipitation effectiveness as determined by any of the other formulae. Such a correlation suggests that the « moisture index» [1] may be expressed simply as a function of precipitation and temperature on the basis of any of the other indices. It could be, for instance, well expressed on the basis of Köppen's $\frac{P}{T+7}$ and the mean function $\frac{P}{T+9}$ as follows.

$$\left.\begin{array}{l} M = 2.3\left(\frac{P}{T+7}\right) - 83.3 \\ \text{and}\quad M = 2.7\left(\frac{P}{T+9}\right) - 90 \end{array}\right\} M = \text{the moisture index}$$

This modification, combined with the modification suggested for determining the « potential evaspiration» shows how Thornthwaite's complicated and laborious method could have been simplified.

[1] The « Moisture Index» is shown by the surplus or deficiency of precipitation in comparison with the « Potential Evaspiration», taking into account that soil can normally store about 10 cm. of precipitation durig the wet season. This amount counteracts a deficiency of an equal amount during the dry season.

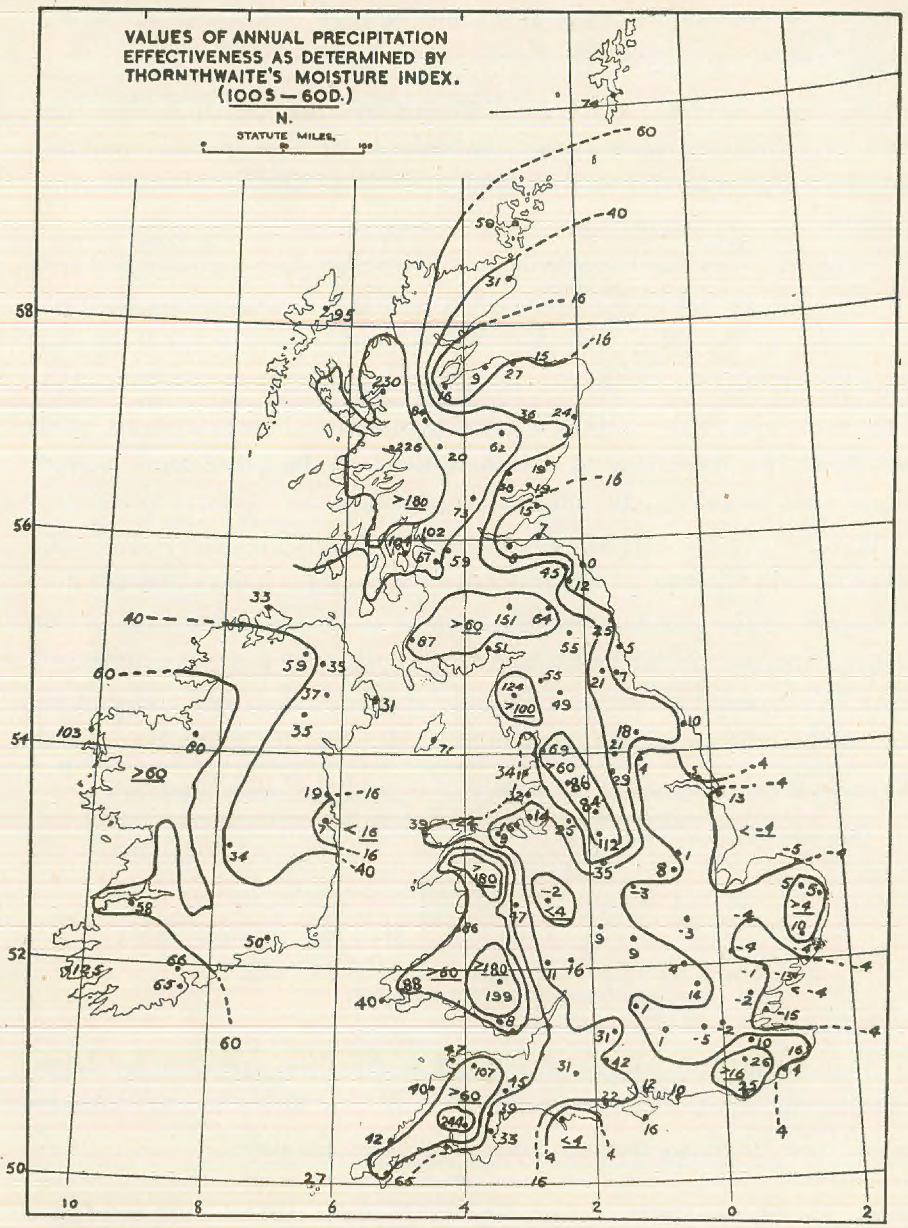
VALUES OF ANNUAL PRECIPITATION
EFFECTIVENESS AS DETERMINED BY
THORNTHWAITE'S MOISTURE INDEX.
(100S — 60D.)
N.
STATUTE MILES.

Fig. 10.

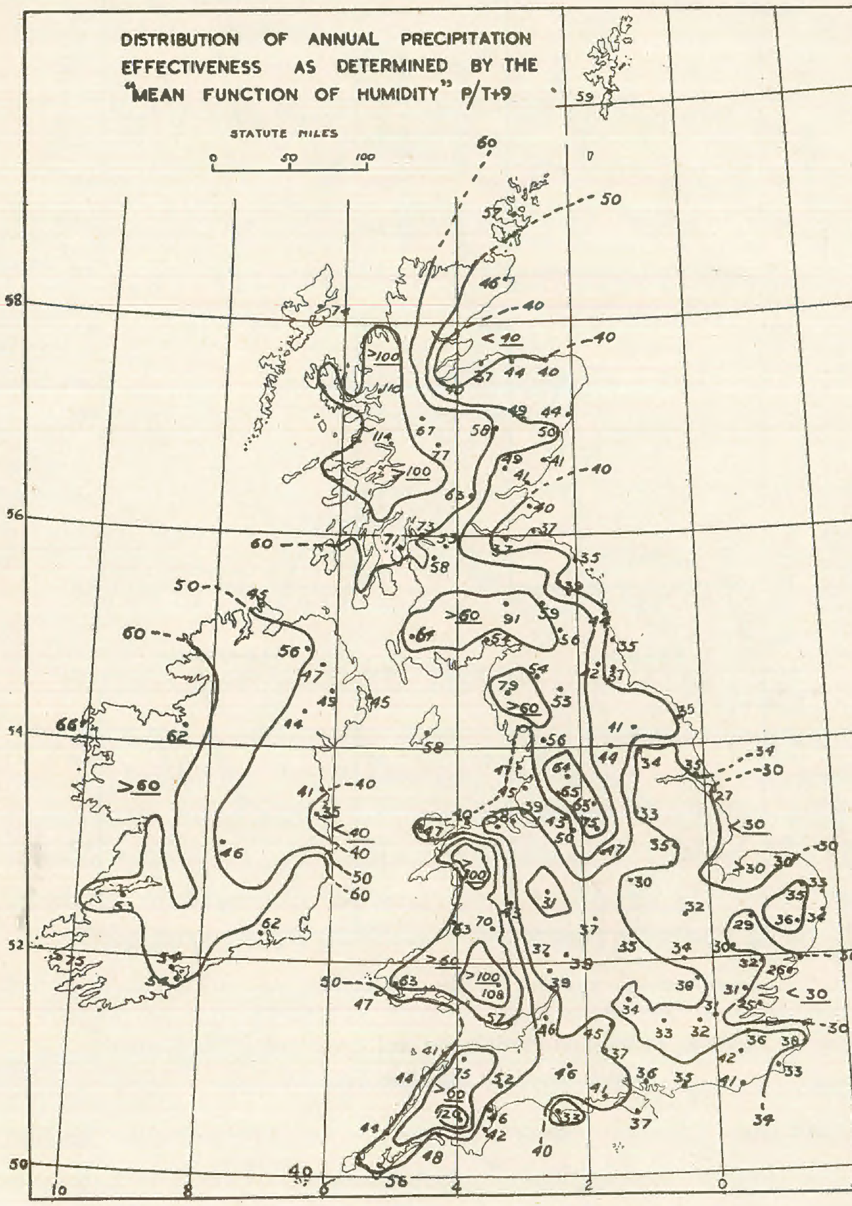
DISTRIBUTION OF ANNUAL PRECIPITATION
EFFECTIVENESS AS DETERMINED BY THE
"MEAN FUNCTION OF HUMIDITY" P/T+9
STATUTE MILES
0
50
100

Fig. 11.

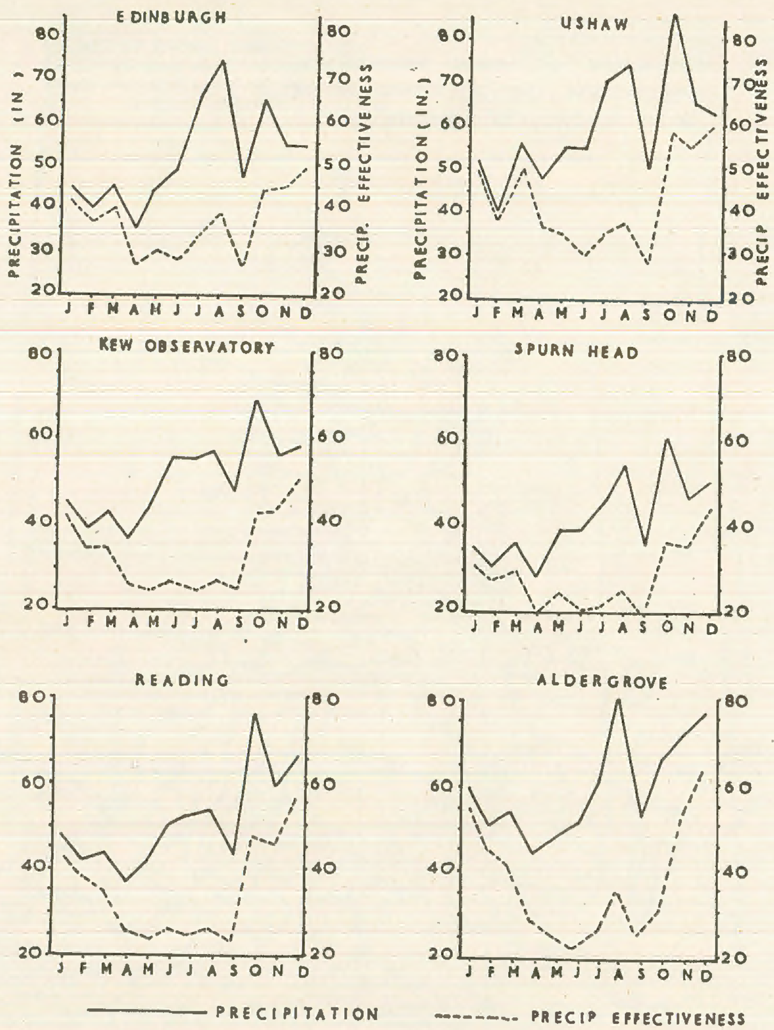

Fig. 12. Variation of Precipitation and Precipitation Effectiveness as Determined by the Mean Function $\frac{P}{T+9}$.

The seasonal distribution of precipitation effectiveness is also noteworthy. The curves of fig. 12 show that the effectiveness of precipitation is higher in winter than in summer. This is, perhaps, the main reason for the dominance of moors and peat in areas where rain forests

could have dominated. It is, therefore, very important to associate the effectiveness of precipitation with temperature conditions and particularly during the growing season.

TABLE VI. *Moisture boundaires calculated by means of various formulae (annual values)*

Moisture divisions	Characteristic vegetation	Mean function $\frac{P}{T+9}$	Köppen 1923	de Martonne 1926	Thornthwaite 1931	Thornthwaite 1948	Setzer 1946
A_1 Most humid	Moor or Rain forests	>60	>64	>52	>96	>60	>600
A_2 Super-humid		50 – 60	54 – 64	44 – 52	80 – 96	40 – 60	500 – 600
B_1 Very humid	Various forests	40 – 50	44 – 54	36 – 44	64 – 80	16 – 40	400 – 500
B_2 Humid		30 – 40	34 – 44	28 – 36	48 – 64	- 4 – 16	300 – 400
C Sub-humid	Grasslands	20 – 30	24 – 34	18 – 28	32 – 48	-20 – - 4	200 – 300
D Semi-arid	Steppes	10 – 20	14 – 24	8 – 18	16 – 32	-40 – -20	100 – 200
E Arid	Deserts	<10	<14	<8	<16	<-40	<100

For formulae see table 5.

CLASSIFICATION OF THE BRITISH CLIMATES

In the light of the foregoing study, the main climatic features of the various parts of the British Isles may be brought under one general Classification, to which further improvements may be introduced. The climatic types of the new classification are shown in the map of fig. 13, which represents broadly the two maps of figs. 1 and 11. Each type is defined by three letters indicating three climatic elements, as given in table VII.

It must be noted, however, that the maps on which the classification is based are not claimed as final on account of the imperfections of the data available. At many stations, for instance, it has been impossible to find temperature data covering the standard period (1906-1935); in such cases data for shorter periods had to be used.

It should be mentioned also that due to the small scale of the maps, several minor climatic features resulting from local topographical variations could not be shown; hence the isopleths of the maps can be

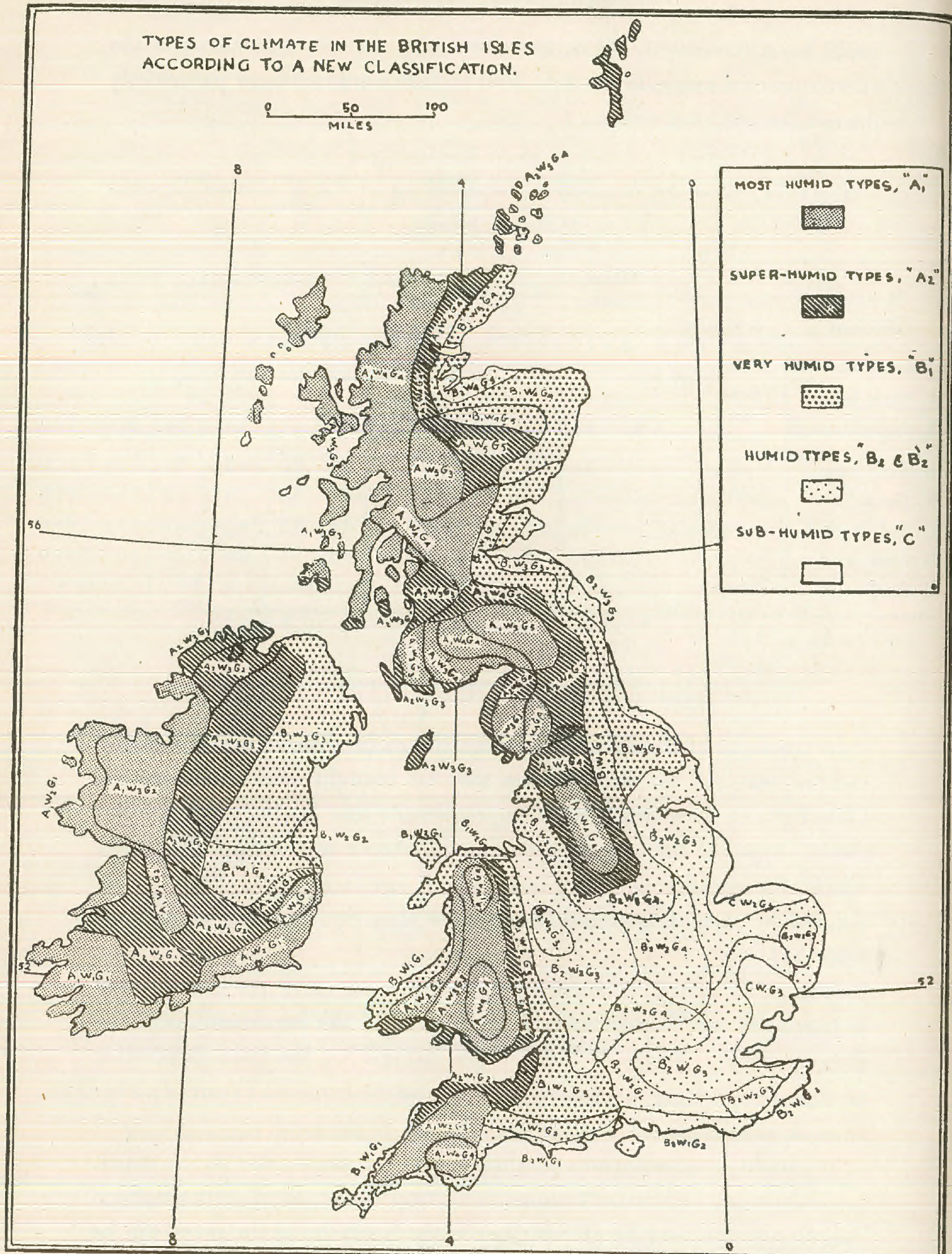

Fig. 13.

regarded only as general boundaries of the major climatic regions. Such a preliminary attempt is therefore an indication of the potentialities of the methods used rather than a final statement of regional divisions.

TABLE VII. *Criteria of various climatic types, regarding precipitation effectiveness, duration of the growing season and accumulated temperature above 42° F.*

Symbols	Annual values of $\frac{\text{Pmm.}}{\text{T° C} + 9}$	Type
A_1	>60	most humid
A_2	$50-60$	super humid
B_1	$40-50$	very humid
B_2	$34-40$	humid
B'_2	$30-34$	humid
C	$20-30$	sub-humid
	Acc. Temp. above 42° F	
W_1	>3100 F°	warm
W_2	$2600-3100$	rather warm
W_3	$2100-2600$	rather cold
W_4	$1600-2100$	cold
W_5	<1600	very cold
	Duration of the growing season (*in days*)	
G_1	>335	
G_2	$275-335$	
G_3	$245-275$	
G_4	$215-245$	
G_5	<215	

Example : At Kew Observatory the precipitation effectiveness is 32, and the accumulated temperature above 42° F. is about 3397 F° and the duration of the growing season is about 273 days, thus the climatic type will be $B'_2\ G_3\ W_1$ *i. e.* humid, warm with a growing season of more than 245 days.

For more detailed regional studies, further subdivisions may also be marked by adding one or more letters espressing other climatic elements such as the seasonal distribution of precipitation effectiveness and

accumulated temperature below 42° F. Such details have had to be overlooked in drawing the map of the present general classification in order to avoid confusion.

Finally, the main climatic types represented in the British Isles, and the areas in which they occur are summarized as follows. Data for certain selected stations are also given to illustrate each type; table 8.

The Most Humid Types, A_1 : These types occur over most of north west Scotland, the Lake District, a small area in the Southern Pennines, most of Wales, the high districts of Cornwall (over 1,000 feet) and considerable areas along the southern and western coasts of Ireland. Further subdivisions may be given as follows.

1. Most humid, warm or rather warm, with a growing season covering almost the whole year ($A_1\ W_1\ G_1$ and $A_1\ W_2\ G_1$), as represented in the western districts of Wales and over large areas in west Ireland.

2. Most humid, rather cold, with at least 245 days as a growing season ($A_1\ W_3\ G_3$); the north western coastal areas of Scotland, the West Isles, and the major part of the Lake District.

3. Most humid, cold, with less than 245 days as a growing season ($A_1\ W_4\ G_4$ and $A_1\ W_4\ G_5$); the highest districts in the west and the north west of Scotland (over 700 feet), the high districts of Wales, Dartmoor and Devonshire (over 1,000 feet) and a smaller area in the Southern Pennines.

4. Most humid, very cold, with less than 215 days as a growing season ($A_1\ W_5\ G_5$); the western slopes of the central Scottish Highlands as well as the western slopes of the central Southern Uplands, the Cheviot Hills and the Northern Pennines.

The Super-Humid Types, A_2 : These are generally found along the eastern limits of the most humid types, due to the general decrease of precipitation from west to east; but they also occur on the western coasts of Britain which, besides being comparatively warmer, receive on the average less precipitation than the adjacent mountain slopes further inland. Further subdivisions may be given as follows :

1. Super humid, warm or rather warm, with an average of 300 days or more for the growing season ($A_2\ W_1\ G_1$, $A_2\ W_2\ G_1$, $A_2\ W_1\ G_2$ and $A_2\ W_2\ G_2$); the north western districts of Lancashire, the northern coast of the Bristol Channel, small areas in southern Cornwall and Devonshire, and a small area in south-west Ireland.

2. Super humid, rather cold, with more than 245 days as growing season ($A_2\ W_3\ G_3$); most of the southern Pennines, the western central plains of Scotland around Glasgow, the coasts of the Lake District, the Isle of Man and a belt of land extending accross Ireland from the northern coast.

3. Super humid, cold or very cold, with a growing season ranging from less than 200 days to more than 215 days ($A_2\ W_4\ G_4$, $A_2\ W_4\ G_5$, $A_2\ W_5\ G_4$ and $A_2\ W_5\ G_5$); the northern islands (Orkney and Shetland), the central and the north eastern districts of Scotland and certain parts of the southern Uplands.

The Very Humid Types, B_1 : These types occur generally in a belt of land extending between north and south to the east of the types of A_1 and A_2. This is particularly clear in Scotland and along the extension of the Pennines. In the southern half of Britain, however, the B_1 types cover most of the western and south western coasts from Blackpool in the north to Torquay in the south. They also cover a considerable area in south west England including almost all Somerset, Wiltshire and a great part of Hampshire. Large areas in the eastern half of Ireland are also included in these types. Further subdivisions may be given as follows.

1. Very humid, warm, with a growing season covering almost the whole year ($B_1\ W_1\ G_1$); the coastal areas of Devonshire and Cornwall, the Scilly Islands, other scattered small areas on the southern coast of England and in the extreme south west of Wales.

2. Very humid, rather warm with an average of more than 275 days for the growing season which often covers the whole year ($B_1\ W_2\ G_1$, $B_1\ W_2\ G_2$ and $B_1\ W_2\ G_3$); considerable areas in the northern and western counties of the Midlands; a belt of land including roughly the northern and north western coastal districts of Wales, the counties of Somerset, Wiltshire and West Hampshire; a large area in south east Ireland.

3. Very humid, rather cold with an average of more than 245 days for the growing season ($B_1\ W_3\ G_2$, $B_1\ W_3\ G_3$ and $B_1\ W_3\ G_4$), in north

east Ireland, south east Scotland and covers most of north east England apart from the eastern coasts. It is interesting to notice that this type in Britain has normally a shorter growing season than in Ireland.

4. Very humid, cold or very cold, with an average growing season ranging from less than 200 to more than 215 days ($B_1 W_4 G_4$, $B_1 W_5 G_4$, $B_1 W_4 G_4$, $B_1 W_4 G_5$ and $B_1 W_5 G_5$); most of the north eastern counties of Scotland.

The Humid Types, B_2 *and* B'_2 : These types cover almost all the low lands of south east Britain except, of course, the areas included in the « C» types. They also occur along the north eastern coast of England and south east Scotland. Further subdivisions may be given as follows.

1. Humid, warm, with a growing season of generally more than 260 days or possibly the whole year ($B_2 W_2 G_2$ or $B'_2 W_2 G_2$); London and its region, the coastal districts of Sussex and Hampshire and the Isle of Wight.

2. Humid, rather warm, with less than 245 days as a growing season ($B_2 W_2 G_4$ or $B'_2 W_2 G_4$); this type is in fact a subdivision of the previous one (no. 1). The main difference is in the duration of the growing season (being somewhat shorter in no. 2 type); it is represented in the East Midlands.

3. Humid, rather cold, with more than 245 days as a growing season ($B_2 W_3 G_3$); north east Yorkshire, the coastal districts of Durham County, Northumberland and south east Scotland.

4. Humid, cold, with an average of less than 245 days for the growing season ($B_2 W_4 G_4$); a small area round the Moray Firth.

The Sub-Humid Types C : These are not represented in the British Isles on a large scale; they occur only in two areas in east England, the first includes the districts bordering the Wash from Cromer (Norfolk) in the south to Spurn Head in the north and the second includes almost all Essex and a part of Suffolk. These two areas may be put under two slightly different subdivisions; the main difference between them is indicated by the amounts of accumulated temperature, which are somewhat lower in the northern area than in the southern, so while the first may be described as rather warm ($CW_2 G_3$) the second is generally warm ($CW_1 G_3$).

TABLE VIII. *Example of various climatic types.*

	PE	AT	Duration and limits of growing season-(days)	Climatic type
A_1 types				
Valentia (Kerry)	75	3224	365	$A_1 W_1 G_1$
Aberystwyth (Cardiganshire....	63	2941	353 (26 Feb. – 13 Jan.)	$A_1 W_2 G_1$
Keswick (Cumberland)........	79	2210	250 (20 Mar. – 25 Nov.)	$A_1 W_3 G_3$
Grieff (Perth)...............	63	2006	223 (2 Apr. – 11 Nov.)	$A_1 W_4 G_4$
Buxton (Derbyshire)..........	75	1977	213 (8 Apr. – 7 Nov.)	$A_1 W_4 G_5$
Dalwinnie (Inverness-shire)....	77	1453	183 (25 Apr. – 21 Oct.)	$A_1 W_5 G_5$
A_2 types				
Falmouth (Cornwall).........	56	3432	365	$A_2 W_1 G_1$
Cullompton (Devon)..........	52	3058	291 (28 Feb. – 15 Dec.)	$A_2 W_2 G_2$
Cork (Cork).................	54	3000	365	$A_2 W_2 G_1$
Cardiff (Glamorgan)..........	57	3145	278 (8 Nov. – 10 Dec.)	$A_2 W_1 G_2$
Glasgow (Lanark)............	53	2364	245 (21 Mar. – 21 Nov.)	$A_2 W_3 G_3$
Lerwick (Shetland)...........	58	1407	227 (20 Apr. – 3 Dec.)	$A_2 W_5 G_4$
Braemar (Aberdeen)..........	58	1467	185 (23 Apr. – 25 Oct.)	$A_2 W_5 G_5$
Bellingham (Northumberland)..	56	1820	191 (19 Apr. – 26 Oct.)	$A_2 W_4 G_5$
B_1 types				
Plymouth (Devon)............	48	3567	365	$B_1 W_1 G_1$
Blackpool (Lancs)............	47	2663	265 (14 Mar. – 3 Dec.)	$B_1 W_2 G_3$
Holyhead (Anglesey)..........	47	2913	365	$B_1 W_2 G_1$
Shaftesbury (Dorset)..........	46	2664	250 (20 Mar. – 25 Nov.)	$B_1 W_2 G_2$
Armagh (Armagh)............	44	2434	260 (14 Mar. – 26 Nov.)	$B_1 W_3 G_3$
Dundee (Angus).............	41	2213	228 (28 Mar. – 11 Nov.)	$B_1 W_3 G_4$
Bradford (Yorks).............	46	2371	236 (22 Mar. – 13 Nov.)	$B_1 W_3 G_4$
Aberdeen (Aberdeen).........	44	1943	229 (2 Apr. – 17 Nov.)	$B_1 W_4 G_4$
B_2 and B'_2 types				
Hull (York).................	35	2722	256 (16 Mar. – 27 Nov.)	$B_2 W_2 G_3$
Oxford (Oxford).............	34	3016	268 (9 Mar. – 1 Dec.)	$B'_2 W_2 G_3$
Yarmouth (Norfolk)..........	33	2935	271 (12 Mar. – 7 Dec.)	$B'_2 W_2 G_3$
Oundle (Northants)..........	32	2643	238 (20 Mar. – 13 Nov.)	$B'_2 W_2 G_4$
Rothamstead (Herts).........	38	2613	243 (20 Mar. – 17 Nov.)	$B_2 W_2 G_4$
Tynemouth (Devon)..........	35	2422	274 (12 Mar. – 8 Dec.)	$B_2 W_3 G_3$
Inverness (Inverness).........	40	2054	237 (25 Mar. – 17 Nov.)	$B_2 W_4 G_4$
C types				
Spurn Head (Yorks)..........	27	2770	268 (15 Mar. – 7 Dec.)	$C W_2 G_3$
Shoeburyness (Essex)........	25	3157	267 (16 Mar. – 7 Dec.)	$C W_2 G_3$
Cromer (Norfolk)............	30	2865	267 (15 Mar. – 6 Dec.)	$C W_2 G_3$

PE — Precipitation Effectiveness

AT — Accumulated Temperature (degrees Fahrenheit)

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ذكتور محمد إبراهيم حسن – المقومات الطبيعية للإستغلال الزراعى فى منخفض الفيـــوم .

تشغل مديرية الفيوم منخفضاً كبيراً فى الصحراء الغربية تزيد مساحته على ألفين من الكيلومترات المربعة ، وهى على اتصال وثيق بالوادى عن طريق فتحة ضيقة يمر منها بحر يوسف ذلك الفرع القديم الذى يحمل المياه والحياة من وادى النيل إلى المنخفض . ويخضع الإستغلال الزراعى فى هذا الإقليم لمقومات طبيعية هامة تتمثل فى مظاهر السطح ونوع التربة ومصادر المياه .

مظاهر السطح :

وقد تكون هذا المنخفض الكبير فى أوائل عصر البلايستوسين بفعل التعرية الهوائية إذ أن الصخور هنا ليست كلها من الحجر الجيرى الصلب بل تتخللها طبقات سميكة من الطين والطفل وتعريتها سهلة . وأهم ما يميز هذا المنخفض أن قاعه ينحدر انحداراً تدريجياً نحو الشمال الغربى إلى بحيرة قارون التى لا يزيد طولها عن ٤٠ كيلومتراً وعرضها عن ١٠ كيلومترات ومستوى سطحها ينخفض عن سطح البحر بنحو ٤٥ متراً . وإلى الجنوب الغربى من مديرية الفيوم يقع منخفض الريان الذى ينفصل عن منخفض الفيوم بحاجز من الحجر الجيرى سمكه نحو ١٥ كيلومتراً . وسعة منخفض الريان تبلغ نحو ٧٠٠ كيلومتراً مربعاً وقاعه منخفض عن سطح البحر بنحو ٥٠ متراً فى أعمق أجزائه .

التربة :

وتغطى قاع المنخفض تربة من طمى النيل . وتختلف هذه التربة فى نظام تركيبها من جهة لأخرى بسبب أثر الظروف المحلية كنظام الإرساب وذبذبة بحر يوسف وانتشار نظام الرى الدائم وظهور بعض الكثبان على جوانب المنخفض .

فالتربة الصفراء التى تبلغ نسبة الصلصال فيها حوالى ٣٠ فى المائة والباقى مواد رملية تظهر على جوانب الترع القديمة والحديثة نتيجة لطبيعة الإرساب . والتربة الصفراء فقيرة فى الفوسفات فلا تصلح كثيراً لزراعة البرسيم والحبوب ولكن تجود بها زراعة الخضروات والموالح والفاكهة .

وتمثل التربة السوداء معظم تربة المنخفض ، وتبلغ نسبة الصلصال فيها أكثر من ٦٠ فى المائة ، وهى تربة متماسكة وتحتفظ برطوبتها مدة طويلة ، ولذلك فهى فى حاجة دائمة إلى حرث عميق . والتربة السوداء غنية فى العناصر المفيدة فى غذاء النبات ، ولكنها فقيرة فى الآزوت ويمكن أن يعوض هذا النقص بالأسمدة الآزوتية وباطالة مدة الشراقى . والتربة السوداء هى أنسب أنواع التربة لزراعة القطن والحبوب .

وترتفع نسبة الأملاح فى الأطراف الشمالية من منخفض الفيوم لضعف انحدارها ولقربها من بحيرة قارون . وقد استصلحت بعض هذه الأراضى بغسلها جيداً وحفر المصارف الثانوية التى تتصل بالمصارف الرئيسية .

وليست كل أراضى الإقليم من تربة طينية خصبة ، إذ تظهر بها بقاع من التربة الرملية الفقيرة . وهذه الجزر الرملية تظهر بوجه خاص إلى الجنوب من طامية وفى منخفض الغرق جنوب غرب الفيوم . وتتكون هذه الجزر من الرمل والحصى وتمثل الأجزاء الصلبة المتماسكة التى لم تغطيها رواسب النيل الطينية . ويمكن استثمار هذه الجهات إذا توفرت مياه النيل اللازمة وإذا جلب بعض الطمى الخصب من الجهات المجاورة لمزجه بالطبقة الرملية السطحية .

مصادر الميـاه :

ويمثل بحر يوسف شريان الرى الرئيسى الذى يحمل مياه النيل إلى منخفض الفيوم . وهو فرع من أفرع النيل كان فيما مضى يخرج من النهر مباشرة قريباً من ديروط ، ولكنه الآن يخرج من ترعة الإبراهيمية . ولا أدل على أنه مجرى طبيعى لا قناة صناعية من كثرة التوائه وانحنائه فى جريانه . وهو يسيل موازياً للنيل تقريباً وإلى غربه حتى يصل إلى بلدة اللاهون فيغير اتجاهه وينحدر مغرباً إلى

أن ينتهى إلى منخفض الفيوم حيث يتشعب إلى ترع عديدة تحمل المياه إلى كل جزء من المنخفض .

ومن أهم ترع الفيوم ترعة عبد الله وهبى التى تروى معظم الجزء الشمالى الشرقى من المنخفض وبحر النزلة الذى يحمل مياه الرى إلى غرب الفيوم . أما بحر الغرق فهو الشريان الرئيسى لمنخفض الغرق ويأخذ من بحر يوسف بعد دخوله المنخفض مباشرة .

وتصرف الفيوم مياهها صرفاً طبيعياً إلى بحيرة قارون وذلك بمصرفين رئيسيين هما مصرف طامية ومصرف الوادى . أما مصرف طامية فيصرف مياه شرق الفيوم ويصل إلى بحيرة قارون فى طرفها الشمالى الشرقى . وأما مصرف الوادى فتتجمع فيه مياه صرف غرب الفيوم ويصب فى بحيرة قارون عند منتصف الشاطىء الجنوبى . وأما منخفض الغرق فيصرف مياهه بمساعدة طلمبات صرف إلى مصرف دانيال الذى يحمل مياه الصرف إلى مصرف الوادى .

وشمال الفيوم خاصة فى حاجة إلى التوسع فى نظام الصرف حتى ينخفض مستوى الماء الباطنى وتصلح الأرض للإستغلال الزراعى .

الدكتور نصرى شكرى (أستاذ الجيولوجيا — جامعة القاهرة) — ملاحظات عن التركيب الجيولوجى لمصر .

ناقش المؤلف علاقة رواسب العصر الكريتاسى (الطباشيرى) برواسب العصر الايوسينى وبيّن أن التركيب الجيولوجى لمصر فى هذه الفترة قد حدد نوع هذه العلاقة — فحيثما وجدت «المرتفعات السورية» ممتدة فى بعض المواقع المصرية فى اتجاه شمال شرقى — جنوب غربى كانت علاقة العصرين المذكورين علاقة عدم توافق تختلف شدتها باختلاف شدة الارتفاع ووقته وموضع الرواسب من «المرتفع» وحيثما وجدت المنخفضات التى تفصل المرتفعات كان الترسيب مستمراً وكانت علاقة العصرين علاقة توافق تامة وقد أرفق المؤلف بالمقال خريطة تبين توزيع أهم «المرتفعات السورية» فى مصر .

الدكتور نصرى شكرى (أستاذ الجيولوجيا — جامعة القاهرة) — جيولوجية جزيرة شدوان بشمال البحر الأحمر .

صاحب المؤلف بعثة الباخرة مباحث فى بعثتها إلى الجزء الشمالى من البحر الأحمر عام ١٩٣٤ — ١٩٣٥ ، حيث درس الجزائر المختلفة فى هذا الجزء من البحر ، وقد سبق له أن نشر مقالا عن جيولوجية جزيرتى الأخوين وفى المقال الحالى يصف المؤلف جيولوجية جزيرة شدوان (إلى الشمال منهما) والتى تتكون أقدم صخورها من صخور أساسية مبلرّة أهمها صخور جرانيتية تقطعها سدود مختلفة ويعلو هذه الصخور المبلرة رواسب من العصر الايوسينى الأسفل والتى يعلوها دون توافق رواسب من عصور الميوسين والبليوبليستوسين والبليستوسين والحديث .

وقد ناقش المؤلف التاريخ والتركيب الجيولوجى للجزيرة وفى رأيه أنها أخذت شكلها الحالى بسبب الفوالق الموازية للبحر الأحمر والتى تسببت عن شد فى هذا الجزء من الأرض وقد نتج عن هذه الفوالق ثنيات محدبة وأخرى مقعرة فى شبه جزيرة سينا وفى الصحراء الشرقية والغربية أهمها مبين فى الخريطة المرفقة بالبحث كما ناقش المؤلف باختصار التركيب الجيولوجى لخليج السويس .

رشدى سعيد — ملاحظات عن جيولوجية صحراء حلوان .

أظهر المؤلف بدراسته لصحراء حلوان أن العامل الأول فى تشكيل جيومورفولوجية المنطقة هو فعل الماء سواء أكان جارياً أم متخللا مسام الصخور المختلفة وأن فعل الريح هو فى النهاية فعل بسيط يقتصر على بعض عمليات النقل وصقل الصخور كما أبان المؤلف فى دراسته أن العامل الأول الذى يقرر الشكل العام للمنطقة هو وجود عدد من الطبقات الجامدة من الحجر الجيرى فى تتابعات الصخور التى تكون المنطقة . وأن هذه الطبقات تعمل كمستويات قاعدة محلية ينحت عليها بواسطة القطع الجانبى المتوازى الصخور التى ترسو عليها وقد عد المؤلف من هذه الطبقات التى تكون فى النهاية أرصفة تعرية أفقية ممتدة امتداداً واسعاً خمسة أسماها شركة الأسمنت وحلوان والمرصد وجروى وحوف .

الدكتور عبد الحليم منتصر (أستاذ النبات بجامعة ابراهيم — القاهرة) — حماية النبات والمحافظة على الطبيعة فى مصر .

١ — مقدمة :

إنه لمن أهمية بمكان ، فى بلد كمصر ، أن نحمى نباتها ، وأن نحافظ على مظاهر الطبيعة فيها ، فان أكثر من ٩٦ فى المائة من مساحتها عبارة عن صحارى قاحلة غير ممطرة ، ونحو ٣ فى المائة فقط من مساحتها عبارة عن أرض زراعية تعتمد كلية على ماء النيل لريها .

وتنقسم مصر إلى سبع مناطق جغرافية ، تتميز كل منها بعوامل بيئية خاصة ، وتنمو بها مجموعة مميزة من النباتات ، وهذه المناطق هى : ١ — الصحارى ٢ — شاطىء البحر الأبيض ٣ — شاطىء البحر الأحمر ٤ — حوض نهر النيل ٥ — شبه جزيرة سينا ٦ — الواحات ٧ — جبل علبه .

وتتوزع نباتات مصر البالغ عددها أكثر من ألف وثمانمائة فى هذه المناطق السبع .

على أن عوامل تدمير النباتات متعددة متباينة ، فالبدو ، وحيوانات الرعى ، والحرائق ، والسيول والفيضانات ، ونشاط الإنسان الزراعى والاقتصادى ، وبناء السدود والقناطر والخزانات ، وشق الترع والمصارف ، ومشروعات الرى والصرف ، ومحطات الصرف الكهربائية ، ومشروعات زيادة الرقعة المنزرعة ، فان من شأن تلك العوامل التأثير الشديد على النباتات ومظاهر الطبيعة فى مصر .

٢ — أثر العوامل الاحيائية من بدو وحيوانات الرعى :

يعتبر وادى « الرشراش » الذى كان مملوكاً للملك السابق ، خير مثال لأثر الحماية والحفظ على النباتات البرية ، ويقع الوادى على بعد ٣٥ ك . م شرقى الصف فى جوف الصحراء ، وكان من أثر الحماية المطلقة أن ازدهرت المجموعات النباتية

أيما ازدهار ، وكانت نباتات السلة والعقول والشويك والرطريط وغيرها يانعة كثيفة تغطى نسبة كبيرة من سطح الأرض — أما النباتات فى الأودية الأخرى مثل دجلة وحوف وعنجبية وغيرها ، وهى التى تتعرض باستمرار لرعى الحيوانات وللبدو الذين يقتلعون النباتات لاستعمالها وقوداً — ولعبث طلاب المدارس فى رحلاتهم ، فان النباتات مبعثرة متناثرة فقيرة . وكان من نتيجة ذلك أن انقرضت أو تضاءلت غابات أتل فى « سينا » وغابات الشورة على شواطىء البحر الأحمر ، ولم تعد توجد إلا فى جزيرة أبى منقار وربما فى بقعة أخرى . وبالمثل تأثر الغردق واللصف والعقول والعدم لأن الحيوانات تقبل عليها وتستطيب طعمها ، على حين أن غيرها مثل الرطريط مما لا يسيغه الحيوان فانه لا يكاد يتأثر . وكذلك تأثر الأراك ، وكان مزدهراً بواديه قرب قنا وأصبحنا نستورده . وكذلك تأثر السكران وهو من النباتات الطبية الشهيرة ، ويعتبر النوع المصرى من أشهر الأنواع وأغناها بالجوهر الفعال ، ولكن البدو يقتلعونه ويبيعونه بأبخس الأثمان . وكذلك يوشك أن ينقرض نبات « بلح الغجر » وهو لا يكاد يوجد فى الوقت الحاضر إلا فى الواحات . وإن منطقة مريوط ذاتها وهى من أغنى مناطق القطر بالنباتات ، ولكن البدو يقتلعون الأزهار فى مواسمها ويبيعونها بأبخس الأثمان مما يؤثر على درجة انتشارها . على حين يرى المار فى تلك المنطقة بالقرب من العلمين بعض الأماكن التى كانت مسرحاً للحرب منذ أكثر من عشر سنوات وقد سورت ومنع المرور بها ، يراها وقد كثف نبتها وازدهر ، وهذا مثل آخر لأثر الحماية ومنع البدو والرعى ، فيتتابع النبت جيلا بعد جيل ، وسنة بعد أخرى ، ويتجمع الخصب موسما بعد آخر .

٣ — أثر مشروعات الرى والصرف :

لقد كان من أثر تعميم نظام الرى الصيفى ، وما يستتبع ذلك من شق الترع والمصارف وبناء للقناطر والسدود والخزانات ، أن انقرضت بعض النباتات من حوض النيل مثل الزقيم ، الذى لا يكاد يرى فى الوقت الحاضر إلا فى منطقة شمال الدلتا وفى منطقة السدود بأعالى النيل . وكذلك انقرض نبات البردى من حوض النهر كله إلا فى منطقة السدود . وكذلك انقرض السرخس المائى « أزولا » على حين بقى

زميله « مارسيليا » لاحتمال الثانى تغير الظروف التى ناء بها الأول . ولا مراء فى أن كثيراً من نباتات مصر الفرعونية قد انقرض على هذه الصورة نتيجة لتلك العوامل .

ولا شك أن أشجار السنط والنبق التى كانت تزدهر خلف خزان أسوان ، قد تلاشت نتيجة غمرها بمياه الخزان ، وكذلك يفعل غيره من السدود أو القناطر التى تقام بين حين وآخر . وكذلك انقرض العرقسوس والغاف وغيرهما نتيجة لهذه العوامل أو تلك .

٤ — الأثر المشترك للعوامل الإحيائية والبيئية على تتابع النبت :

من المعلوم أن تتابع النبت فى منطقة ما يأخذ طريقاً محدوداً تبعاً للعوامل المختلفة المهيمنة على تلك البيئة . ويختلف هذا الطريق إذا كانت النشأة الأولى على صخر أو رمل أو على الماء ، وإنها لتبدأ على الصخر بأشن قشرية تتبعها أخرى ورقية أو شجرية ثم تليها الأعشاب فالشجيرات والأشجار ، وكل طور من هذه الأطوار يهيىء البيئة للطور الذى يليه ، ويجعلها مستحيلة بالنسبة لنفسه ، فيتحول الصخر مع الزمن وبفعل النبات والجو إلى تربة ذات رطوبة ودبال ، يزدهر بها نبت شجرى كثيف .

ولا شك أن كل طور من هذه الأطوار يمكن أن يتأثر أو يقف نتيجة للأثر المشترك لهذه العوامل مجتمعة ، من رعى أو رى أو صرف أو زراعة . وطبيعى أن هذه العوامل لا تؤثر على النباتات الزهرية الراقية وحدها ولكنها تؤثر كذلك على الكائنات المجهرية الدقيقية من فطريات وطحالب وأشنه وغيرها ، مما يعمر التربة والماء على السواء .

ومن المحقق أن من الواجب العناية بحماية هذه النباتات ، وعمل مجموعات منظمة لها ووقاية النباتات الأصيلة لمنطقة ما ، حتى لا تنقرض نهائياً يوماً من الأيام ، ومحاولة استنباتها وحمايتها فى أماكن معينة .

٥ — كيف نحمى النباتات ونحافظ على الطبيعة :

١) ينبغى المبادرة إلى عمل ثبت بأسماء النباتات ومدى انتشارها فى المناطق البيئية المختلفة . وإجراء دراسات علمية بيئية على هذه النباتات .

٢) تنظيم دراسات علمية عن البيئة الذاتية لهذه النباتات ، ونشر هذه الدراسات على أيدى إخصائيين مدربين .

٣) إقامة حديقة نباتية فى كل منطقة ، وزراعة حقول تجارب ، لدراسة أحوال هذه النباتات وطرق تكاثرها ، وإجراء تجارب علمية مختلفة عليها ، وإنه ليستتبع ذلك حتما إنشاء قنوات أو سدود أو صوب أو كهوف أو جبلايات لتربية هذه النباتات .

٤) اختيار أماكن معينة فى كل منطقة بيئية وإحاطتها بسور ، ومنع البدو أو حيوانات الرعى من الاقتراب منها ، وبالجملة حمايتها من جميع عوامل التدمير ، لتبقى ممثلة للبيئة الطبيعية للمنطقة .

٥) وغير خاف أن بعض شواطئنا تتآكل بفعل مياه البحر ، كما فى البرلس ورأس البر ، وقد يلزم إنشاء بعض الأرصفة لحماية هـذه الشواطىء ، فنحمى بذلك الشاطىء وتربته وأهله من هذا العامل المدمر .

٦) ضرورة استشارة اخصائى فى علم البيئة النباتية عند تنفيذ مشروعات الرى والصرف والإصلاح .

٧) ولا بد مع ذلك من نشر الوعى الطبيعى بين الجماهير وطلاب المدارس ، وتستخدم لذلك كل أساليب التعليم من إذاعة وسينما وبرامج التعليم والصحف والرحلات والنشرات والإعلانات ، حتى ينشأ جيل مثقف يحب طبيعة بلاده ويتعشقها ، ويحمى مناظرها ومظاهرها ونباتها من كل عامل مدمر .

الدكتور عبد الحليم منتصر (أستاذ النبات — جامعة ابراهيم — القاهرة) — عوامل البيئـة وتوزيع النباتات فى مصر .

تنقسم مصر إلى سبع مناطق جغرافية ، ينمو بها ما يزيد على ١٨٠٠ من الأنواع النباتية .

وهذه المناطق هى :

١ — شاطىء البحر الأبيض
٢ — شاطىء البحر الأحمر
٣ — الصحراء
٤ — حوض النيل
٥ — الواحات
٦ — سيناء
٧ — جبل علبة

ومن النباتات ما ينمو فى خمس مناطق أو أكثر ، ومنها ما ينمو فى أى منطقة ولا يختص بواحدة ، ومنها ما ينمو فى منطقة واحدة دون غيرها من المناطق . ومعظم صور النبات ممثلة فى النباتات المصرية بدرجة مقبولة عدا الأشجار الباسقة والمتوسطة فانها لا تكاد توجد . والغرض من هذا البحث دراسة عوامل البيئة ذات الأثر على توزيع هذه النباتات فى المناطق الجغرافية المختلفة ، وقد درست العوامل الجوية الآتية :

١ — درجة الحرارة
٢ — كمية المطر
٣ — درجة الرطوبة
٤ — سرعة الريح والعواصف الرملية
٥ — البخر
٦ — الندى
٧ — درجة حرارة التربة
٨ — الضوء

كما درست عوامل التربة الآتية :

١ — التحليل الميكانيكى
٢ — المحتوى المائى للتربة ، والنهاية العظمى للسعة المائية .
٣ — الكربونات
٤ — الدبال
٥ — الأملاح الذائبة
٦ — الأزوتات
٧ — الرقم الايدروجينى

ثم درس أثر هذه العوامل على نمو وتوزيع النباتات على النحو الآتى :

١ — أثر عوامل التربة على نمو النبات
٢ — الضغط الأسموزى لعصير النبات
٣ — أثر عمق البذر على إنبات البذور
٤ — التباين فى مواسم الإنبات
٥ — نفاذية التربة ونمو الجذر
٦ — أثر عوامل التربة على نمو الجذور
٧ — أثر عوامل التربة على الوزن الجاف للمجموعين الخضرى والجذرى

وقد اتخذت العريش والسلوم لتمثل منطقة شاطىء البحر الأبيض المتوسط ، كما اتخذت الغردقة والقصير والسويس لتمثل شاطىء البحر الأحمر ، وهليوبوليس وحلوان لتمثل منطقة الصحراء ، والفيوم وطنطا وأسيوط لتمثل حوض النيل ، وسيوه والداخلة لتمثل الواحات ونخل لتمثل سينا ، أما جبل علبة فلم نتيسر دراسته فى هذا البحث المقارن .

وقد أجريت مقارنة العوامل الجوية المختلفة فى المناطق الجغرافية فى مصر ، كما قورنت عوامل التربة المختلفة فى المناطق ذاتها ، ودرس أثر تلك العوامل على توزيع النباتات فى مصر ، وقد ثبت أن عدداً من النباتات يبدى مرونة شديدة ، ويحتمل ظروفاً وعوامل متباينة . فبعض النباتات يحتمل درجات متفاوتة من المحتوى المائى أو الأملاح أو الكربونات أو الدبال أو الرقم الايدروجينى ، على حين أن بعضها الآخر ليست له هذه المرونة . ومن أمثلة ذلك نبات السلة الذى ينمو فى تربة نسبة الكربونات بها تتراوح بين ٠,١ ٪ و ٢٥ ٪ ونبات القرمل Zygophyllum simplex وينمو فى تربة نسبة الكربونات بها بين ٠,١٣ ٪ و ٤٢,٢٩ ٪ .

وبعض المناطق تتميز بقلة الكربونات فى تربتها مثل طريق السويس (الخمسين كيلو الأولى) وألماظة ووادى ملاحه وعنجيبة والسقى والجبل الأصفر ، فنسبتها فيها تتراوح بين ٠,١ ٪ و ٥ ٪ . وبعضها غنى بالكربونات مثل دجله وحوف والرشراش حيث تتراوح نسبتها بين ١٠ و ٤٠ ٪ .

وبعض النباتات لا يتأثر كثيراً باختلاف نسبة الكربونات ، وأنه ليزدهر قلت هذه النسبة أو كثرت ، على حين أن بعضها الآخر لا يكاد يوجد إلا حيث تعلو

نسبة الكربونات ، ومثال الحالة الأولى نبات القرمل *Zygophyllum simplex* ومثال الحالة الثانية *Z. coccineum*

والأراضى المصرية قلوية بوجه عام ، ونسبة الدبال بها قليلة ، ويتراوح معدل الرقم الايدروجينى بين ٧,٢ — ٩,١ ، وتقل القلوية قليلا كلما تعمقنا فى التربة ، ويعزى ذلك إلى عامل البخر الذى يرفع الأملاح إلى الطبقات العليا . أما فى الجهات المطيرة فان الحموضة تنقص كلما تعمقنا فى التربة ، لأن المطر يغسل الأملاح إلى الطبقات السفلى . وإنه ليلاحظ اتساع المعدل الذى تحتمله النباتات من تباين الرقم الايدروجينى ، وكذا تباين بعض العوامل الأخرى من جوية أو تربية ، وقد ثبت ذلك لا للنباتات الأصيلة فى منطقة ما فحسب ، بل وأيضاً للنباتات التى تنمو فى مناطق جغرافية مختلفة ؟

مايريلوز وچورچ كنتش — الخطوط التركيبية فى حوض النيل وحوله

وضع سؤالان فى مقـدمة هذا البحث السؤال الأول يتعلق بتطور نهر كبير ، داخل إطاره التركيبي .

والإجابة عن هذا السؤال هى أن « حوض النيل » مماثل من حيث التركيب لأحواض « أفريقيا العليا » التى تتاخمها غالباً على جانبيها الشمالى الغربى والشمالى الشرقى ارتفاعات مائلة . ويمكن مقابلة حوض النيل أيضاً بالأحواض الشرقية للمحيط الهندى ، حيث يشاهد انحراف « تدفقى » أو انحراف « سينى » وهذا دليل على أن مركزه الكراتونى « عميق » أكثر مما هو « مرتفع » (Stille 1935) وقد تم تكوينه على وجه التحقيق خارج « الدرقة الأفريقية نفسها » وداخل أجزاء جرفها الجيولوجى . وكان نظام الحياض معروفاً بلا شك قبل وجود نهر النيل ، ولكنه أخذ يتشوه ببطء وما زال يتشوه .

وأجزاء الشلالات تشير إلى حركات التواء ، موازية لتركيبات D القديمة . بيد أن النهر لم يستطع دائماً مقاومة الالتواء ، فكان أحياناً فى خلال تاريخه ينسد لمدة من الزمن .

والسؤال الثانى هو : هل المميزات التركيبية الصغرى لحوضى النيل الأسفلين — وهى عبارة عن مجارى كثيفة متفاوتة بين الكفاية وعدم الكفاية — تدل أم لا تدل على وجود قاعدة عامة للالتواء .

وقد اتضح أنها مطابقة للتركيبات الكبرى . وأجرى تحليلها عن طريق تقدير سواعدها الجافة (الوديان) التى تسير طبقاً لخطوط تركيبه .

وفضلا عن ذلك ، فقد رجح أن النيل كان قبل العصر البليوسينى يجرى بين الفيوم والواحات البحرية وأنه لم يتخذ طريقه الأسفل الحالى إلا فى نهاية العصر الميوسينى أو فى أوائل العصر البليوسينى . وذلك عندما أصبح مثلث الدلتا التركيبى أرضاً جافة بصفة نهائية — ويقال أن نظاماً محلياً للصرف وضع وقتئذ فى الأراضى المتاخمة مباشرة للدلتا بقصد حجز مياه النيل الأسفل .

وأجرى بحث تركيبى للصحراء الغربية وللمركز التركينى فى منخفضات الواحة مما أدى إلى بعض الملاحظات المتعلقة بأصلها ونشوءها — وقد شرح ذلك شرحاً افتراضياً مؤداه وجود منحـــدرات مياه كيمائية قوية فى أمكنة ذات تركيبات من شأنها السماح للمياه الجوفية بالتدفق داخلها . وهذه المياه الجوفية قد تراكمت فيها محاليل آسنة أدت إلى إتلاف الطبقة الحجرية ، أما المواد المتحللة فقد تناثرت فى الريح .

ولا يرجح وجود تأكلات ناشئة عن الرياح العاصفة .

الدكتور عبد العزيز طريح شرف — ملخص الأسس التى بنى عليها التقسيم الجديد لمناخ الجزر البريطانيـــة .

من المتفق عليه تقريباً فى الوقت الحاضر أن المعدلات المناخية الخاصة بدرجة الحرارة والأمطار لا تعطى فى كثير من الأحيان صورة صادقة لحقيقة العلاقة بين هذين العنصرين من جهة وبين المظاهر الحيوية وغير الحيوية فوق سطح الأرض من جهة أخرى . إلا أن الجغرافيين لا يزالون ، رغم اعترافهم بهذه الحقيقة ، يتبعون فى دراساتهم المناخية الطريقة التقليدية التى كانت ولا تزال تتبع منذ أن بدأت عناصر المناخ تقاس وتسجل نتائج قياسها بانتظام فى أوائل القرن التاسع عشر ، وملخصها هو أن توزع المعدلات الخاصة بكل عنصر من عناصر المناخ على الخريطة ثم نوصل الأماكن التى تتساوى معدلاتها بخطوط تعرف باسم خطوط الظاهرات المتساوية Isopleths أو Isographs

ولكننا نرى أن الوقت قد حان لكى يحاول الجغرافيون تعديل هذه الطريقة وذلك بجعلها أكثر تمشياً مع نتائج الأبحاث الحديثة فى علم المناخ نفسه وفى بعض العلوم الأخرى المتصلة به ، ومن أهمها علوم الهيدرولوجيا والنبات والزراعة . والبحث المنشور هنا ليس إلا محاولة أولية لبيان الطريقة التى يمكن بها الاستفادة من نتائج هذه الأبحاث فى دراسة مناخ إقليم معين .

وتمتاز الطريقة المقترحة ، فضلا عن استفادتها بنتائج الأبحاث الحديثة ، بأنها تجعل المعلومات المناخية أكثر واقعية وأكثر فائدة للباحثين فى العلوم الأخرى ، لأنها تعطى لهم هذه المعلومات فى الصورة التى يحتاجون إليها فى دراساتهم .

القيمة الفعلية لدرجة الحرارة

تعتبر القيمة الفعلية لدرجة الحرارة أحد الأسس التى بنى عليها التقسيم الجديد ، وقد اتبعت فى تقدير هذه القيمة عدة طرق يمكن تقسيمها إلى نوعين :

أولا — طرق تجريبية ؛ وذلك باجراء تجارب خاصة (فى المعـــامل) على

نباتات معينة لتقدير سرعة نموها فى درجات الحرارة المختلفة ، ورغم أن إجراء مثل هذه التجارب يعتبر غالباً من اختصاص الباحثين فى علم النبات فان هذا يجب ألا يحول بين الجغرافيين وبين الاستفادة من نتائجها ؛ إلا أننا يجب ألا نغالى فى الاعتماد على هذه النتائج لأنها لا تمثل فى الغالب ما يحدث فى الطبيعة فعلا ، لأن الظروف التى تجرى فيها التجارب تكون غالباً ظروفا صناعية يحدد بواسطتها أثر كل عنصر من العناصر التى تؤثر فى حياة النبات بصورة يندر أن تتفق مع ما يتعرض له هذا النبات فى بيئته الطبيعيه ، خصوصاً وأن درجة الحرارة لا تمثل فى الواقع إلا عاملا واحداً من عوامل متعددة تتدخل فى حياة النبات وتؤثر فى سرعة نموه .

ثانياً — تحديد فصل النمو وتقدير مجموع الوحدات الحرارية التى تتوفر أثناءه فوق الحد الأدنى اللازم لنمو النباتات بصفة عامة « صفر النمو » ؛ . وقد صادفت هذه الطريقة قبولا عاماً فى السنوات الأخيرة من جانب الباحثين فى علم المناخ ، وهى تمتاز عن الطرق التجريبية من عدة وجوه أهمها :

١ — أنها أبسط منها بكثير حتى أنه من الممكن تطبيقها بسهولة فى الدراسات المناخية لأن كل ما يلزم لتطبيقها هو المعدلات الشهرية لدرجة الحرارة .

٢ — أنها تحاول دراسة العلاقة بين درجة الحرارة والحياة النباتية كما هى موجودة فعلا فى الطبيعة .

٣ — أنها تستند إلى بعض المبادىء المتفق عليها بين معظم الباحثين فى علمى المناخ والنبات ومن أهمها أن كل نبات يحتاج لكى يتم نموه ونضجه إلى عدد معين من الوحدات الحرارية التى يجب أن تتجمع أثناء حياته فوق « صفر النمو » .

فصل النمو :

هو الفترة التى لا ينخفض أثناءها المتوسط اليومى لدرجة الحرارة عن صفر النمو بالنسبة لغالبية النباتات ، وهذا الصفر فى رأى معظم الباحثين هو المتوسط اليومى ٤٣° ف ، أو ٤٢° (كما هو متبع فى بريطانيا) ؛ وتحديد فصل النمو بهذا الرقم أو ذاك ليس فى الحقيقة إلا تحديداً عاماً قد لا ينطبق على كثير من الأنواع والفصائل النباتية ، فبعض النباتات تستطيع أن تنمو فى درجة حرارة أعلا أو أقل من غيرها ،

فبينما يبدأ القمح مثلا نموه عندما يكون المتوسط اليومى ٣٧° ف نجد أن الذرة والقطن لا يبدأ نموهما إلا إذا ارتفع هـــذا المتوسط إلى ٥٥°ف بالنسبة للأول و٦٢° بالنسبة للثانى

الحرارة المتجمعة :

ويقصد بها مجموع الوحدات الحرارية التى تتجمع فوق « صفر النمو » ويمكن حسابها ليوم واحد أو لأسبوع أو شهر أو لأى فترة أخرى ، إلا أن المعتاد هو حسابها لفصل النمو بأكمله ، والحرارة المتجمعة لأى يوم هى الفرق بين متوسط درجة حرارته وصفر النمو ، والحرارة المتجمعة لأى شهر هى مجموع الدرجات المتجمعة فى كل أيام هذا الشهر ؛ وقد اقترحنا طريقة مبسطة لحسابها تتلخص فى المعادلة الآتية : م : (ح — ٤٢) × عدد أيام الشهر[1] ؛ وهذه الطريقة أبسط بكثير من الطريقة التى تتبعها الآن مصلحة الأرصاد الجوية فى بريطانيا وبمقتضاها تحسب الحرارة المتجمعة لكل يوم على حدة بواسطة معادلات وجداول خاصة تستخدم فيها النهايات العظمى والصغرى لدرجات الحرارة اليومية ، وقد أوضحنا بالتفصيل كيف أن هذه الطريقة الأخيرة رغم تعقيدها ورغم ما يحتاجه تطبيقها من وقت ومجهود ليست أدق من الطريقة المبسطة التى اقترحناها .

ومعرفة الحرارة المتجمعة لفصل النمو له أهمية كبيرة بالنسبة للحياة النباتية بصفة عامة وللتوسع الزراعى فى الأقاليم الباردة بصفة خاصة ، لأنه هو الذى يحدد نوع الغلات التى يمكن زراعتها فى هذه الأقاليم ، وقد ساعد هذا النوع من الدراسة على استغلال بعض الأراضى الواقعة إلى الشمال من الدائرة القطبية فى زراعة بعض أصناف القمح وغيره من المحاصيل .

ويلاحظ أن الحرارة المتجمعة يمكن أن تحسب كذلك تحت صفر النمو أو تحت أى حد آخر يقع الاختيار عليه ، ويكون ذلك لأغراض أهمها تقدير ما يلزم من الوقود للاستهلاك فى المصانع والمنازل وغيرها خلال الأشهر التى يشتد فيها البرد .

(1) م = الحرارة المتجمعة ، ح = المتوسط اليومى لدرجة حرارة الشهر (درجات فهرنهيتية)

القيمة الفعلية للأمطار :

من الحقائق المعروفة أن الحياة النباتية والحيوانية بما فى ذلك الإنسان لا يمكنها أن تستفيد بكل ما يسقط على سطح الأرض من مياه الأمطار ، وذلك لأن مقاديراً كبيرة منها تعود إلى الجو بطريقين هما :

١ — التبخر من المسطحات والمجارى المائية أو من سطح التربة .

٢ — النتح من النباتات .

وتقدير نسبة ما يضيع من مياه الأمطار بالطريقين السابق ذكرهما مهم جداً بالنسبة للتوسع الزراعى فى الأقاليم قليلة الأمطار ، إلا أن هذا التقدير لا يزال يعتبر من أعقد المشاكل التى تواجه الباحثين سواء فى علم المناخ أو فى العلوم الأخرى المتصلة به ، وذلك لعدم وجود طرق سهلة متفق عليها لقياس البخر والنتح ، وللتغلب على هذه الصعوبة حاول بعض الباحثين أن يقدروا القيمة الفعلية للأمطار بطرق حسابية معينة ، فرأى البعض (مثل كوين وديمارتون) أن درجة الحرارة يمكن أن تصلح أساساً لتقدير هذه القيمة لأن البخر والنتح يتناسبان معها تناسباً طردياً بصفة عامة .

ويعتبر ثورنثويت كذلك من أشهر الباحثين الذين حاولوا تقدير القيمة الفعلية للأمطار ، وقد اقترح فى سنة ١٩٤٨ طريقة معينة لتقدير هذه القيمة ، ولكن على الرغم من أن الأساس الذى بنيت عليه هذه الطريقة هو وجود معامل لارتباط مرتفع بين درجة الحرارة من جهة والقيمة الفعلية للأمطار من جهة أخرى ، وهو أساس بسيط فى حد ذاته ، فان ثورنثويت اتبع فى تطبيقها أسلوباً معقداً بدرجة لا تشجع طالب الجغرافيا على الاستفادة بها فى الدراسات المناخيه .

وقد بينا بوضوح بعد تطبيق هذه الطريقة فى الجزر البريطانية ومقارنة نتائجها بنتائج تطبيق بعض الطرق والمعادلات التى اقترحها باحثون آخرون أن كثيراً من الخطوات التى اقترحها ثورنثويت كان من الممكن تجنبها أو تبسيطها بدرجة كبيرة دون أن تفقد الطريقة شيئاً من قيمتها .

القيمة الفعلية للأمطار فى الجزر البريطانية :

يبين الجدول رقم ٥ المعادلات التى حسبت بمقتضاها القيمة الفعلية للأمطار فى الجزر البريطانية والحدود التى اقترحها أصحاب هذه المعادلات للأنواع المناخية والنباتية المختلفة .

وقد توصلنا بعد تحليل هذه المعادلات ومقارنتها ومقارنة نتائجها إلى اقتراح حدود مناخية جديدة تمثلها المعادلة الآتية : $E: \frac{P}{T+9}$ ؛ على اعتبار أن E هى القيمة الفعلية للأمطار و P هى متوسط كمية المطر السنوى بالمليمترات و T هى معدل درجة الحرارة بالدرجات المئوية .

والحدود المقترحة ليست فى الواقع إلا متوسط الحدود التى اقترحها الكتاب الآخرون — راجع الأشكال ٨ و ٩ و ١١ .

أهم الأنواع المناخية فى الجزر البريطانية :

فى ضوء الدراسة السابق تلخيصها أمكن تقسيم مناخ الجزر البريطانية إلى عدة أنواع كما هو موضح فى الخريطة شكل (١٣) وهذه الخريطة عبارة عن ملخص عام للأقسام التى وردت فى الخرائط الثلاثة التى توضح : طول فصل النمو شكل (١) ، والحرارة المتجمعة فوق ٤٢° ف خلال فصل النمو شكل (٢) والقيمة الفعلية للأمطار شكل (١١) . ويبين الجدول رقم ٧ الحدود المختلفة التى بنى عليها التقسيم والرموز التى ميز بواسطتها كل نوع .

ويلاحظ أن كل نوع من هذه الأنواع يحدد بثلاثة رموز ، يمثل الأول منها درجة الرطوبة كما تدل عليها القيمة الفعلية للأمطار ، والثانى مبلغ الدفء أو البرودة كما تدل عليها الحرارة المتجمعة . بينما يمثل الرمز الثالث طول فصل النمو ؛ وقد أوردنا فى الجدول رقم (٨) أمثلة معينة للأنواع المختلفة .

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